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HOME
ABOUT THE BANK
BONDS & SECURITIES
CURRENCY
MONETARY POLICY
PRESS RELEASES
PUBLICATIONS & RESEARCH
RATES & STATISTICS
Contact the Bank
Glossary
Search
Site Index
FRANÇAIS

CONFERENCE

Money, Monetary Policy, and Transmission Mechanisms

Proceedings of a conference held by the Bank of Canada, November 1999

Introduction HTML
Kevin Clinton and Walter Engert

Opening Remarks
Jack Selody

Session 1: Measuring Money PDF

Measuring Transactions Money in a World of Financial Innovation
Jean-Pierre Aubry and Loretta Nott

Discussion: *Angela Redish*
Discussion: *William Robson*
General Discussion

Broad Money: A Guide for Monetary Policy PDF
Kim McPhail

Discussion: *Alain Paquet*
Discussion: *Tony S. Wirjanto*
General Discussion

Monetary Aggregates and Monetary Policy PDF
Apostolos Serletis and Terence E. Molik

Discussion: *Joseph Atta-Mensah*
Discussion: *Seamus Hogan*
General Discussion

Session 2: Policy Applications

PDF

The M1 Vector-Error-Correction Model: Some Extensions and Applications
Charleen Adam and Scott Hendry

Discussion: *Stefan Gerlach*
Discussion: *Shamik Dhar*
General Discussion

Swiss Monetary Policy under a Flexible Exchange Rate Regime: Monetary Targets in Practice
Michel Peytrignet

PDF

Discussion: *Chantal Dupasquier*
Discussion: *Daniel Racette*
General Discussion

Measuring the Stance of Monetary Policy
Ben S.C. Fung and Mingwei Yuan

PDF

Discussion: *Frank Smets*
Discussion: *Sharon Kozicki*
General Discussion

Session 3: Theory

PDF

Financial Intermediation, Beliefs, and the Transmission Mechanism
Robert Amano, Scott Hendry, and Guang-Jia Zhang

Discussion: *Paul Gomme*
Discussion: *Sylvain Leduc*
General Discussion

Credit Crunch, Bank Lending, and Monetary Policy: A Model of Financial Intermediation with Heterogeneous Projects
Mingwei Yuan and Christian Zimmermann

PDF

Discussion: *Emanuela Cardia*
Discussion: *Shouyong Shi*

The Expectations Trap Hypothesis

PDF

Lawrence J. Christiano and Christopher Gust

Discussion: *Tiff Macklem*
Discussion: *David Andolfatto*
General Discussion

Session 4: Panel Discussion

PDF

Discussion 1: *Charles Freedman*
Discussion 2: *Marvin Goodfriend*
Discussion 3: *David Laidler*
General Discussion

The Participants

PDF

List of participants

Search

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Wed, 21 March 2001

[illegible]
ABOUT THE BANK
[illegible]
CURRENCY
MONETARY POLICY
PRESS RELEASES
PUBLICATIONS & RESEARCH
RATES & STATISTICS
Contact the Bank
Glossary
Search
Site index
[illegible]

■ CONFERENCE

Money, Monetary Policy, and Transmission Mechanisms

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Table of Contents

Introduction

Kevin Clinton and Walter Engert

The 1999 Bank of Canada conference, *Money, Monetary Policy, and Transmission Mechanisms*, involved a variety of participants from the Bank, academia, and other central banks, such as the U.S. Federal Reserve System, the Bank of England, the European Central Bank, and the Swiss National Bank, as well as representatives from the Organisation for Economic Co-operation and Development and the Bank for International Settlements.

Major Themes of the Conference

Three major themes emerged in the conference and they are likely to have a continuing impact on research and policy advice at the Bank of Canada. The first concerned uncertainty about the transmission mechanism and about the models to use in monetary policy decision-making. This leads to the idea that the central bank has to make use of all available insights from monetary policy research. Accordingly, participants at the conference stressed that the central bank should not rely on just one class of model for its forecasting and policy simulations, arguing that the central bank should consider, among other approaches, projections based on monetary and financial variables along with more conventional projections based on an aggregate demand function and a Phillips curve. Since no single model can contain all the mechanisms or channels that might be at work in the transmission of monetary policy, central bankers ought to rely on a variety of approaches, or paradigms, to inform their decision-making. The conference recognized the usefulness of a menu of models that might be consulted in addition to the mainstream macroeconomic model.

The second major theme of the conference concerned the potential usefulness of monetary aggregates as a guide to keep the economy on a stable, non-inflationary path. This could become more important as output reaches the zone of full employment, where the order of magnitude of the output gap is the same as the margin of its measurement error. However, at the same time, conference participants noted that financial innovation makes movements in monetary aggregates difficult to interpret. Different approaches were explored to deal with the instability in the relationships among money, prices, and output. These included close monitoring of innovations of financial products along with a readiness to change definitions of both broad and narrow monetary aggregates. It was also stressed that central banks should focus more on the longer-term evolution of monetary aggregates. Conference participants also explored the idea of treating transactions balances as an unobservable variable (like potential output), the quantity of which can be inferred from a well-specified model.

Finally, the conference explored recent developments in monetary general-equilibrium models, which can yield valuable insights into the economy's workings. However, conference participants generally felt that such models, while promising, need further development to become part of the regular tool kit of monetary policy-makers. In particular, in order to account for the nominal dynamics that are evident in the economy, it is important that researchers address more explicitly the role of financial intermediation and financial markets in dynamic general-equilibrium models.

An Overview of the Papers

The conference began with a topic that has a long history—the appropriate role of monetary aggregates in the conduct of monetary policy. In Canada broad money and narrow money have behaved differently over the cycle and over the long run, and the two concepts seem to contain different information about inflation and the economy more generally. The M1 aggregate has been viewed as a potential guide for policy in the light of findings that it has been a leading indicator in the short run for output and, over a somewhat longer run, for inflation.

In their paper **Jean-Pierre Aubry** and **Loretta Nott** attempt to strengthen the link between theory and fact by examining the components of a narrow definition of money for an aggregate that behaves consistently with theory and that is not too sensitive to financial innovations. They argue that the composition and nature of deposit products used for transactions have changed enormously over the past 25 years. The innovations came in two waves. During the first, from 1978 to 1986, banks and other financial institutions offered innovations, e.g., daily-interest chequing and savings accounts, and corporate cash-management packages. This led to a shift away from demand deposits. The second wave followed the introduction of the zero fractional reserve requirement in 1992. Banks began offering very competitive rates on large demand deposits, which had previously been burdened with higher reserve requirements. At the same time, wealth-holders began to accumulate large "free-credit" balances at the investment dealer subsidiaries of the banks, these balances also being classified as demand deposits. The rapid expansion of these balances was associated with the mutual funds boom—investors temporarily place their funds in free-credit balances while deciding on more permanent investments. Thus, in the middle of the decade, M1 experienced a bulge, which reflected the building up of means to manage portfolios rather than an accumulation of transactions balances to be spent on goods and services.

Aubry and Nott show that the quantities involved in these waves of innovation were very large: Their estimates indicate a shift out of M1 of about 30 per cent in the first wave of innovation and into M1 of up to 45 per cent in the second. They conclude that, to capture such shifts, the definition of transactions money in Canada needs to be broader than traditional M1. They suggest that it is unlikely that an unchanging narrow aggregate, generated as a fixed combination of existing financial instruments, will exhibit a stable relationship with prices and output over time. The central bank should, therefore, monitor a range of definitions, looking out for shifts in the use of the various components by studying institutional developments closely.

The usefulness of broad money as a guide for policy in Canada is looked at by **Kim McPhail**. The recent adoption of a reference rate for a broad definition of money by the new European Central Bank has given added interest to this issue. McPhail applies two criteria. First, there should be a stable long-run estimated demand function. This would quantify the relationship between money and prices, taking into account other variables influencing the demand for money, but need not specify a direction of causality. Second, the aggregate should provide reliable leading information on inflation, at a horizon of one or two years, additional to that contained in other variables. This would be consistent with conventional views on the transmission lag in monetary policy and with the idea that money growth may be influenced by inflation expectations.

Contending definitions of broad money comprise a vast continuum of components, which go from a very high to a much lower degree of liquidity. Since theory provides little guide as to the selection of a cut-off point, McPhail studies a wide array of definitions. She searches for stable demand functions over 30 years of data, using the Johansen-Juselius method to identify cointegrating vectors (which represent long-run relationships). Unit price-level elasticity (a one-for-one percentage response of prices to a change in money) is imposed on the relationship, since this is a strong theoretical requirement. For most definitions of broad money two such vectors can be found, one of which corresponds to a stable long-run demand function. Overall, the results suggest that the kinds of innovation that plagued the demand for the narrow aggregate, M1, are adequately internalized within the broader aggregates. McPhail tests the ability to predict inflation on the basis of single-equation models that include, as well as current money growth, the deviation between actual money and the estimated long-run demand for it (the "money gap"), and the measure of the output gap from the Bank's Quarterly Projection Model. It turns out that the inclusion of broad aggregates does result in more accurate predictions of inflation at both 4- and 8-quarter horizons and that this result stems from money growth rather than the money-gap terms. Such findings are in line with the standard quantity theory, which holds that inflation is caused by past money growth without spelling out a precise transmission mechanism, but provide no support for the buffer-stock hypothesis, which is typically related to money gaps. While the results seem to be fairly robust across definitions, McPhail is able to identify two broad aggregates that consistently perform well—both include Canada Savings Bonds and, alternatively, either total mutual funds or mutual funds sponsored by financial institutions.

A more sophisticated approach to constructing monetary aggregates employs weighted components instead of the conventional summations. Since in theory the conditions required for the validity of the latter are quite severe, **Apostolos Serletis** and **Terence Molik** compare two measures derived from index number principles—divisia and currency equivalent—against simple-sum counterparts, applying three different weighting schemes to five definitions of money. A battery of tests is applied: cyclical correlations of variables (detrended by the Hodrick-Prescott method), cointegration tests, single-equation causality tests, and vector autoregressions (VARs). The authors find that for all the aggregates they try, money is not cointegrated with prices or income, suggesting that real money balances and velocity are nonstationary variables. This would imply difficulties for monetary targeting. Nevertheless, causality tests, especially for the divisia M1++ aggregate, suggest that aggregates might provide useful information with respect to prices and aggregate demand.

A different perspective on the use of monetary aggregates is provided by **Charleen Adam** and **Scott Hendry**. Policy actions affect inflation only with a considerable lag, so that policy-makers need help, for example, in assessing whether policy actions are likely to have the desired effect. Models can help to this end, and given the uncertainties about the real world, the authors stress the benefits of employing a variety of models—based on different views of the transmission mechanism—to assist in formulating monetary policy.

In Canada this raises the question of how M1, which earlier research has found to have valuable leading-indicator properties, might be used to help in inflation targeting. Adam and Hendry consider the M1-based vector-error-correction model (M1 VECM), which features an active-money (or buffer-stock) interpretation of the monetary transmission mechanism. They devise a technique for removing the distortions described by Aubry and Nott from M1 and re-estimate the model on the resulting adjusted measure. Their approach essentially treats M1 as an unobservable variable that can be inferred from the model.

Adam and Hendry's version of the M1 VECM forecasts inflation well. Impulse-response experiments with the model confirm that shocks to the overnight interest rate represent unexpected monetary policy actions. Consistent with this finding, an assumed monetary policy rule can be incorporated in the model to give the hypothetical short-term interest rate response to deviations from an assumed target path for M1. Various experiments, which Adam and Hendry illustrate, are then possible, such as finding a path for the overnight rate necessary to achieve a given rate of inflation over a particular horizon. An interesting technical feature of this work is that for each experiment, confidence bands around the predicted outcomes can be derived.

In the light of the success of the low-inflation monetary policy in Switzerland over many years, the approach used by the Swiss National Bank (SNB) merits attention. **Michel Peytrignet** provides a discussion on how monetary aggregates were used by the Swiss National Bank for may years.(1) He describes how monetary policy aimed at maintaining price stability, using a monetary aggregate as an intermediate objective. Reflecting the SNB's pragmatic attitude, the definition of money changed over time in response to economic and structural changes; however, a continuing aspect was that central bank money had always been featured explicitly. Central bank money, sometimes known as the monetary base, is equivalent to the central bank's liabilities to the private sector; i.e., currency in circulation plus bank reserves. This very narrow aggregate appeals to monetary theorists and practitioners alike because it can be directly controlled by the central bank (at least in principle) and because it can be precisely observed day-by-day. Moreover, since demand for the monetary base is not highly responsive to market interest rates, movements in the monetary base will be a better reflection of policy actions' actual impact on the economy. (In contrast, Canadian M1 is so sensitive to interest rates that its movements tend to overstate this impact.) However, the SNB has never set out to unconditionally achieve a given quantitative path, and various developments often led to substantial deviations from previously announced annual targets. These have included major exchange rate shocks, which cannot be ignored in a highly open small economy and which led to unusually persistent inflation pressures in the early 1990s. Another source of shock has been the introduction of new payments technologies.

To provide more flexibility for dealing with such events, in the 1990s the money-target horizons have been lengthened to the medium term; that is, five years or thereabouts. The target rate of growth for central bank money, 1 per cent, was set on the assumption that it would be roughly consistent with inflation at the same rate. That is, expected long-run output growth of about 2 per cent would be roughly accommodated by the trend increase in velocity arising from innovations to payments practices. Peytrignet concludes that the intermediate target had provided an effective means for keeping the longer term in view and thereby for taking preventive decisions. Not much seemed to depend on the precise definition of money as long as it had credibility—which is a function mainly of actual performance and careful communications by the central bank.

Ben S.C. Fung and **Mingwei Yuan** take a different approach to exploiting the potential information in monetary aggregates (and other financial variables) for the purposes of a central bank. They construct a quantitative measure of the stance of monetary policy aimed at indicating whether policy is tight, easy, or neutral relative to the objective of keeping inflation constant. More specifically, Fung and Yuan hypothesize that the stance of monetary policy is reflected in a weighted set of financial variables. The variables considered include the M1 monetary aggregate, the term spread, the overnight interest rate, and the exchange rate. The stance of monetary policy is expressed as a linear combination of these four variables with their relative weights determined from a (just-identified) VAR model. The authors find that of the four variables considered in the stance measure, only the overnight rate plays a significant role in capturing monetary policy action.

Fung and Yuan use their stance measure to study the Bank of Canada's policy actions over the years, examining the impulse-response functions of the orthogonalized innovations to the stance measure and so considering the dynamic responses of other variables in the VAR to monetary policy shocks. The results are consistent with the expected effects of a monetary policy shock: Following an expansionary policy shock the interest rate and the term spread decline, output and the price level increase, and the Canadian dollar depreciates relative to the U.S. dollar. Fung and Yuan also find that the time series of the policy shocks is consistent with the historical record of monetary policy actions. Their analysis also suggests that the Bank of Canada generally does not respond vigorously to contemporaneous surprises in the credit market and the exchange rate. This is consistent with the fact that the Bank does not target the exchange rate, but only acts to smooth the change in the exchange rate to avoid disruption to financial markets.

On the second day of the conference, discussion moved on to a topic that is at the leading edge of current monetary research—dynamic general-equilibrium modelling. In their work **Robert Amano**, **Scott Hendry**, and **Guang-Jia Zhang** emphasize the role of financial intermediaries. In particular, they focus on the role that liquid assets can play in the decision-making of financial intermediaries and so in the transmission of monetary policy actions. They extend a standard limited-participation model by incorporating financial intermediaries that optimize profits by allocating funds between long-term loans and shorter-term liquid assets. Another feature of the model is the existence of asymmetric information between private banks and the monetary authority with respect to the intentions of the central bank.

Their analysis suggests that an expansionary policy may have smaller but more protracted effects on an economy when the public does not clearly understand the intent of a monetary policy action and financial intermediaries have choices between long-term lending and shorter-term investment in liquid assets. When financial intermediaries invest in liquid assets, there is a smaller positive real impact of a monetary easing and less inflationary pressure in the goods market: Liquidity that might otherwise have been lent to firms is held in the liquid-asset market instead. Banks release new liquidity into the lending market only once they are certain that the central bank will not unwind the injection of extra liquidity in the near future. This monetary effect is driven by the financial intermediaries' interpretation of monetary policy. Misinterpretation of the stance and direction of monetary policy can occur for a variety of reasons including low policy credibility, policy shocks, or an environment characterized by other financial market shocks that complicate financial institutions' efforts to understand the stance and direction of monetary policy.

Consistent with empirical observation, the effects of monetary policy actions are variable in this model. When the true intent of policy is clear, the transmission lag between the policy action and the economy is relatively short. In contrast, when the direction of monetary policy is unclear, the effect of monetary policy on output and inflation is more muted and occurs with a longer lag. In sum, the effects of monetary policy actions in this class of model depend on the degree to which information frictions exist and on the ability of banks to adjust their lending behaviour in view of such frictions. More generally, Amano, Hendry, and Zhang argue that these results suggest the importance of incorporating a meaningful financial sector in monetary general-equilibrium models so as to generate dynamic responses that correspond better to empirical results.

Mingwei Yuan and **Christian Zimmermann** also explore the role of financial intermediaries in the transmission mechanism, but from a different perspective, one focused on the credit channel. They develop a dynamic heterogeneous agent model to study credit crunches and the effectiveness of monetary policy in that context. In this model a credit crunch is caused by banks' conservative lending behaviour during periods of reduced profitability and financial distress. In particular, the banks in this model can allocate their assets to loans or risk-free government securities. Banks manage their risk by choosing investments to satisfy a target loss/deposit ratio (derived from a benchmark or normal state of the economy). This ratio is binding when there is a downturn, and as a result the model generates a credit crunch in such a manner that banks will reallocate their assets from loans to government securities. This in turn magnifies the overall reduction in lending and economic activity.

Yuan and Zimmermann then consider some experiments with their model. Given a credit crunch, a monetary policy easing leads banks to lend to some smaller firms, but the banks still hold a large proportion of their assets in government securities. As a result the policy easing is relatively ineffective in ameliorating the credit crunch effects. In a second experiment the banks are allowed to relax their target loss/deposit ratio, and this change is much more effective in stimulating economic activity. These results suggest that the relative effectiveness of monetary policy can be reduced in the face of a protracted credit crunch. More generally, this work points to the potential importance of the behaviour of financial intermediaries—as well as rules that aim to underpin financial stability— in transmitting monetary policy actions.

Finally, **Lawrence Christiano** and **Christopher Gust** explore reasons for the inflation takeoff in the 1970s. Of particular interest to the authors is the Federal Reserve's motivation that led to rapid monetary expansion in the United States. Christiano and Gust hypothesize that a rise in inflation expectations created a virtually irresistible incentive for the increased money growth, an incentive they call an "expectations trap."

Christiano and Gust explore this hypothesis in a limited-participation model that incorporates a monetary policy rule estimated for the 1970s, when the response of the Federal Reserve to anticipated inflation was relatively weak. In their model, following a negative technology shock, output and employment fall and inflation rises. The central bank reacts to the increase in inflation expectations by reducing liquidity to push up interest rates. However, given the accommodative 1970s-style reaction function, private agents understand that the nominal interest rate will go up by less than the increase in inflation expectations, so that expected real interest rates would fall.

With an expected decline in real interest rates, private agents reduce their savings deposits; they drain funds from the financial intermediaries. To compensate and to try to attenuate the upward pressure on nominal interest rates, the central bank injects liquidity into the financial intermediaries, fulfilling the inflation expectations. Nevertheless, the rise in interest rates and the increased inflation that coincides with these developments produce a fall in output and employment, and the resulting stagflation persists for years in the model.

Christiano and Gust also show that a more aggressive response in their model to the jump in inflation expectations would improve subsequent economic performance. With a less accommodating monetary policy following the productivity shock, output and employment would be better maintained, and inflation would be lower as well. Finally, they argue that, in contrast to the limited-participation model, a conventional sticky-price IS-LM model cannot account for the major features of the 1970s. In particular, they argue that the IS-LM model predicts that a self-fulfilling outburst of inflation is associated with an *increase* in employment and output, at odds with the experience of the 1970s.

Christiano and Gust conclude that avoiding future expectations traps and self-fulfilling inflation outbursts requires properly designed monetary policy institutions. These should put the central bank's commitment to price stability beyond doubt, so that jumps in inflation expectations will not occur in the first place.

Panellists' Comments

Three different perspectives are evident in the panellists' commentaries. **Charles Freedman** traced the evolution of research and the use of monetary aggregates at the Bank of Canada. Modelling has become more sophisticated, and increased attention has been paid to longer-run empirical relationships with the application of cointegration techniques. The VECM approach has taken centre stage in the Bank's analysis of M1. At the same time the Bank has continued to carefully examine the effects of innovations on the demand for money and to consider whether new measures might be more helpful.

The Bank has also adopted a new approach towards assessing the information contained in the monetary aggregates and comparing this assessment with the staff projection (derived from a model in which money plays no explicit role). Economists from the Department of Monetary and Financial Analysis now make a separate presentation at the

Bank's formal quarterly projection meeting of the alternative forecasts derived from the aggregates. (The Bank's regional representatives also give an independent assessment of the outlook based on their surveys of about 100 businesses across the country.) The weight that will be placed on the various sources of information will ultimately depend on their track record. Economic activity in Canada is currently approaching potential, at least according to traditional measures of capacity output. But since there is considerable uncertainty about these measures, the Bank is placing increasing weight on various indicators of future inflation, including the monetary aggregates. Freedman also observed that since a short-term interest rate is the instrument of policy, central bankers have found it difficult to accept the idea that policy exogenously sets the money supply. The development of models in which money is endogenous and yet an active influence on the economy has helped central bankers to agree that money balances might capture shocks not picked up elsewhere in mainstream models.

Monetary general-equilibrium models contain a key role for financial intermediaries and yield some interesting insights. However, Freedman thought that to gain acceptance in the tool kit of practising central bankers, these models would have to incorporate more recognizable features of actual financial systems. Perhaps if general-equilibrium modellers worked more closely with central bank specialists in financial structure there would be a fruitful two-way interchange.

The other central banker on the panel, **Marvin Goodfriend**, discussed why the macroeconomic models currently at the fore of monetary policy analysis make no reference to the behaviour of money. One reason for this is that since central banks have already established credibility for control over the price level, nominal interest rate policy changes translate directly into real interest rate changes. This favourable situation could break down. It was the collapse of credibility in the 1970s that caused the U.S. Federal Reserve to move away from a federal funds rate target to a quantitative policy instrument from 1979 to 1982.

Money deserves a special place in the strategy of monetary policy, and circumstances may arise in which it becomes a necessary element. Building the public's confidence in a central banks's ability to reverse an inflation or a deflation would minimize beforehand the likelihood of such problems. Goodfriend (and later David Laidler) went on to describe a process in which changes in money in themselves contain inflationary or deflationary shocks above and beyond those captured by short-term interest rates.

Goodfriend added that because policy actions and economic shocks are intertwined, econometricians have to be quite careful in using techniques such as VARs in empirical studies of monetary policy. Goodfriend felt that an autoregressive structure may be too restrictive to capture policy responses to the lagged effects of unintended past shocks imparted by the policy instrument itself. These are likely to be more prominent in the current situation, in which central banks generally simply want to hold inflation at about where it is and hence to avoid policy shocks.

David Laidler took a distinctly different tack on the potential role of the money supply. He suggested that monetary aggregates might be less useful to policy in periods of unstable price levels because monetary instability was itself likely to erode existing empirical regularities, as illustrated by the difficulties with monetary targeting in the 1970s and 1980s. Milton Friedman's money-growth rule was originally put forward in the 1950s as a means of ensuring that low inflation and steady growth, which had been achieved, would be maintained.

Low inflation has been restored in the 1990s using a macroeconomic framework in which monetary aggregates play no visible role. But now that the output gap is less than the margin of error in its measurement, the main problem for monetary policy has reverted to keeping a well-performing economy out of trouble. Laidler thought that the monetary aggregates are well-adapted to this task, since their role in determining the long-run time path of inflation is uncontroversial and since in Canada narrow aggregates were useful leading indicators of output. He admitted, however, that there was not a case for the reinstatement of monetary targeting because the problems associated with institutional change have not gone away.

Laidler concluded by encouraging monetary general-equilibrium modellers to pay more attention to the money-creating activities of financial intermediaries. He recognized that this was a very difficult task, but the payoff could be a better understanding of why deposits, particularly those usable for transactions, seem to play a causal role in spending decisions. This would increase our confidence in the information that we extract from the behaviour of monetary aggregates.

Opening Remarks

Jack Selody

Welcome to our conference on money, monetary policy, and transmission mechanisms. I think you will find that we have put together a very stimulating conference on how central bankers ought to use money in their deliberations on monetary policy.

This conference draws heavily on the research that Bank of Canada economists have done in the normal course of providing advice to monetary policy-makers. A conference like this one gives our researchers the opportunity to get feedback from their academic colleagues and their counterparts in other central banks. I hope that it also encourages others to do more work in this area and that they will share this work with us at the Bank.

It should come as no surprise to most of you that there has been much debate among economists at the Bank about the appropriate weight to give monetary aggregates when formulating monetary policy advice. This conference is intended to highlight the reasons why monetary aggregates have not taken centre stage in monetary policy deliberations and to move the debate forward by proposing new ways in which central bankers can think about the transmission mechanism.

When we started thinking about the possibility of a conference on how central bankers might expand their use of monetary aggregates, we knew that there was compelling evidence that monetary aggregates could be used as indicators for monetary policy. There was no need to revisit this territory once again. Rather, it seemed to us that the knock against money was that trusting the monetary aggregates was often seen as too risky. There appeared to be three reasons for this reluctance to trust money.

First, monetary aggregates sometimes move in unpredictable ways. Such episodes can be large and long-lasting, and have caught central bankers by surprise at times in the past. Sometimes these surprises are the result of new economic information about a change in the future course of output and prices. At other times these surprises reflect a change in the transmission mechanism, perhaps because new information technology has changed the way businesses manage their cash and set their prices. It is at these times that monetary aggregates can be a valuable tool for monetary policy. At still other times, however, such movements are simply distortions to the monetary aggregates and convey no economic information. An example of such a distortion would be the introduction of a new debit card that turned savings balances into transactions balances. Such distortions must be recognized early and understood if monetary aggregates are to merit greater weight in monetary policy deliberations. The issue here is how to separate distortion from economic information about the future. Jean-Pierre Aubry and Loretta Nott examine episodes of instability in the monetary aggregates in an attempt to make such a separation. Apostolos Serletis and Terence Molik propose new ways of constructing monetary aggregates that could be less affected by this problem.

Second, output and prices do not always respond in the same way to movements in monetary aggregates. This makes empirical models with fixed-lag structures unreliable in practice. One reason why these models may be unstable is that money is being used to finance types of economic activity not captured by the GDP, such as increased stock market activity. Alternatively, it may be that the models focus too much on the short-run relationship between money, prices, and output, and should instead focus more on the longer-run relationship. The issue here is how to obtain stable empirical models of the transmission mechanism. In an attempt to find stable empirical models, Charleen Adam and Scott Hendry use transactions money, and Kim McPhail uses a broader definition of money, to look at whether their models' forecasting properties are improved by recognizing the long-run relationship between money, output, and prices.

Third, it will come as no surprise to this audience that our theoretical understanding of the transmission mechanism remains uncertain and incomplete. Lawrence Christiano and Christopher Gust highlight this uncertainty by looking at two quite different models of the transmission mechanism. The lesson I take away from their paper is that it would be unwise to base policy advice on a single view of the transmission mechanism.

Another area of considerable controversy is the role of financial intermediation in the transmission mechanism. I, for one, think financial intermediation lies at the heart of the transmission mechanism, yet many economists use models in which financial intermediaries are passive agents in the transmission mechanism. The issue here is the best way to expand our theoretical knowledge about the role financial intermediaries play in the economy. Bob Amano, Scott Hendry, and Guang-Jia Zhang take the approach of putting a rudimentary financial intermediary into the standard limited-participation model. Christian Zimmermann and Mingwei Yuan take a different approach; they introduce riskless and risky investments into the standard limited-participation model which, when combined with a conservative risk-management strategy on the part of banks, is sufficient to generate a credit crunch when monetary policy is tight.

I now turn to issues of how central bankers ought to use monetary aggregates in their policy deliberations. On this subject there is probably greater agreement on how *not* to use monetary aggregates than on how to use them.

It is widely acknowledged that a monetary aggregate is not the instrument of monetary policy in Canada, nor should it be under current institutional arrangements. The instrument of monetary policy in Canada is the overnight rate of interest.

I think it is also fair to say that no one at the Bank of Canada advocates the use of a monetary aggregate to replace the core consumer price index as the final target for monetary policy. Inflation targeting has been working effectively and I see no reason for change. Nevertheless, given the long lag between the instrument of monetary policy and its goal, some see merit in using a reference range for a monetary aggregate as a communications device. The use of such a range would provide more timely feedback about the success of monetary policy actions than can be provided by an inflation target alone. But a reference range for money would augment, not replace, the inflation target. Michel Peytrignet describes the Swiss National Bank's success in using a monetary aggregate as a communications device. The challenge for us in Canada is to find ways of predicting and explaining episodes during which money might deviate from its reference range for reasons unrelated to inflationary pressure.

Somewhat more controversial is the role that monetary aggregates should play in gauging the stance of monetary policy or in the monetary policy reaction function. Ben Fung and Mingwei Yuan show that a monetary aggregate contributes little to their measure of the stance of monetary policy in Canada, perhaps because the monetary authorities have not paid a lot of attention to monetary aggregates in the past. The issue here is whether monetary policy would have been better had the monetary authorities taken movements in monetary aggregates more seriously.

One thing I hope everyone at this conference will agree on is that monetary indicators do contain information about future movements in inflation and therefore should enter monetary policy deliberations in some form. As well, I think everyone would agree that well-balanced monetary policy advice should take account of different views of the transmission mechanism.

In launching this conference I would like to thank all those who contributed to making it happen. In particular I would like to thank the speakers, the discussants, and the Bank employees who are acting as scribes. I would also like to thank Diane Hammond, Sylvie Dubois, Fern Monast, and Gisèle Bousquet for their dedicated work on the conference logistics. Finally, I thank Kevin Clinton and Walter Engert for their work putting this conference together.

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1. In December 1999, the Swiss National Bank modified its monetary policy framework to focus on an explicit inflation target. At that time, the Swiss National Bank also announced that it would no longer fix money supply targets but that the money stock (as measured by the aggregate M3) would continue to play an important role as a monetary indicator.

Table of Contents

Top of Page

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Measuring Transactions Money in a World of Financial Innovation

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Introduction and Summary

It is generally accepted among macroeconomists that a relationship exists between money, output, and prices. A change in the money supply immediately affects financial variables such as interest rates, exchange rates, and asset prices. Changes in these variables affect the liquidity position of financial institutions, and this in turn influences the liquidity of firms and households and their spending decisions. In the short run this chain of events will affect employment and output, while nominal wages and prices will respond with longer lags.

Monetary aggregates, the sum of a subset of holdings of financial instruments by households and firms, enable economists to evaluate the relationship between money, output, and prices. Monetary exchange is seen as the defining characteristic of money and the condition needed to set the monetary transmission mechanism in motion, so an aggregate that most closely reflects transactions is often used to estimate this relationship.[1] Moreover, because the objective of monetary policy is the stability of an

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[1] Some economists think that the defining characteristic of money is its liquid store of value, and so they support the use of broader aggregates to study the relationship between money, output, and prices. For a more detailed examination of this school of thought, see McPhail (2000).

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aggregate price for goods and services, economists also seek a monetary aggregate that would closely reflect transactions for goods and services.

In an uncertain world, economic agents hold an inventory of cash, which likely varies over time, to buffer against shocks to income that might otherwise disturb their preferred pattern of purchases of goods, services, and financial assets. When a discrepancy between actual and long-run desired money holdings exists, it is a sign that economic agents will engage in monetary exchange to alter the flow of expenditures until money holdings return to their desired level. This process sets in motion a real balance, which is transmitted from agent to agent, triggering prices to rise. Thus, money as a medium of exchange is fundamental to the theory that fluctuations in money affect prices.[2] Transactions money is central to the buffer-stock theory, the cash-in-advance theory, or the search theory of the transmission mechanism.

The narrow aggregate, M1, defined as the sum of both currency held outside banks and demand deposits at chartered banks, has been the commonly used measure of transactions money in Canada during the last 30 years. M1 is intended to measure the money that economic agents hold for the purpose of settling transactions. However, the ability to measure transactions money and evaluate its relationship with output[3] and prices has been greatly altered over the last 30 years by two major waves of financial innovation.

In the first wave, from about 1978 to 1986, financial institutions offered new types of deposits that affected the opportunity cost of holding money and induced depositors to differently optimize their holdings of transactions balances. These new products included daily-interest chequing and savings accounts (which were not included in M1) and corporate cash-management packages. We estimate that the first wave gradually reduced the level of M1 by approximately 30 per cent as individuals and firms shifted transactions balances from traditional demand deposits into new types of deposits classified outside M1.

Around 1993 a second wave of financial innovation began to affect M1. As mutual funds grew, notice deposits held by the household sector started to be used less as savings vehicles, and demand deposits, which are included in M1 and which include investment dealer accounts, became less closely tied to transactions for purchasing goods and services and more to transactions related to the sale and purchase of financial assets. For the business sector the additional incentives for using current accounts (included in M1) encouraged some firms to use these accounts for temporary savings as well as for transactions purposes. Our estimates suggest that, to date, the second wave of innovation, which is a mix of supply and demand shocks, has increased the level of M1 by up to 45 per cent as individuals and firms use traditional M1 deposits increasingly as a store of liquid value rather than as a pure transactions instrument.

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[2] See Laidler (1999) for details of this characterization of the transmission mechanism.

[3] Real GDP (referred to as output) is the most commonly used variable as a proxy for the aggregate volume of transactions for purchasing goods, services, and financial assets.

As a result of these two waves of financial innovation, M1 has become less adequate and less stable as a representation of the financial instruments used to purchase goods and services. Hence, the relationship between M1, output, and prices has become less clear, and ability to use M1 as a guide for conducting monetary policy has been reduced.

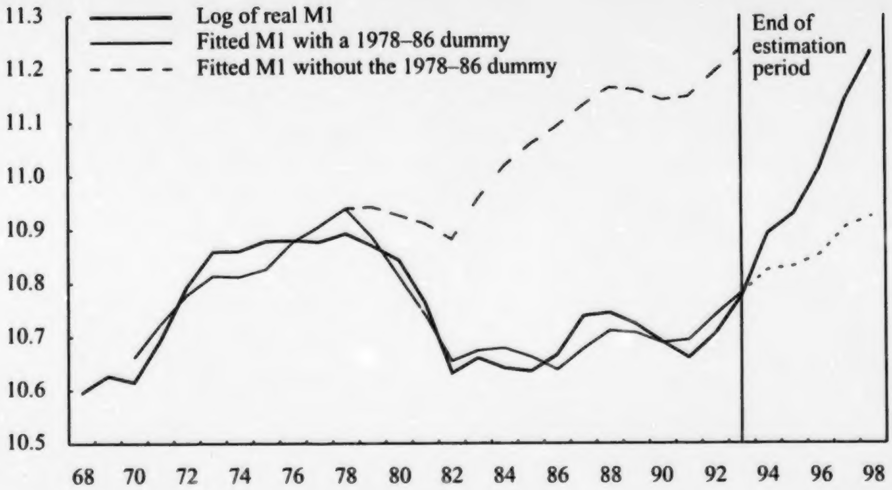
This paper discusses the issues of using narrow-money aggregates as a guide for policy in a world of financial innovation. We hope that further work will be able to identify and measure apparent instabilities in the holding of transactions balances, thereby enabling the construction of stable narrow monetary aggregates. We will show that in order to reduce the instability caused by waves of financial innovation, a robust measure must reflect the evolution of the financial instruments used for transactions purposes. Thus, a narrow monetary aggregate that aims to capture the money used for transactions must reflect agents' evolving choices of transactions instruments and the evolving menu offered to them. Failing to do this requires that great care must be applied in extracting information from a single imperfect narrow aggregate, and monitoring various definitions of narrow aggregates would be even more important for the conduct of monetary policy.

The remainder of this paper is organized as follows. Section 1 examines how in the past 30 years the M1 measure has not kept up with financial innovations and hence has become an inadequate representation of transactions money. Section 2 describes how financial innovations have affected the empirical relationship between narrow-money aggregates, output, and prices. Section 3 proposes work toward an aggregate that responds contemporaneously to financial innovation and briefly discusses the expected gains from such work.

1 Financial Innovation, Instability, and the Demand for M1

Typical money-demand equations, using real GDP and short-term interest rates as explanatory variables, cannot closely track the profile of real M1 during two subperiods of the past 30 years. This point is illustrated in Figure 1, which compares the profile of the logarithm of real M1 with the

Figure 1
Gross M1



Note: Estimation period: 1970–93 (annual frequency).

$$\ln(M1/CPI) = \underset{(0.4)}{0.8} + \underset{(4.7)}{0.78}*\ln(GDP) - \underset{(-3.7)}{0.12}(0.5*R90 + 0.5*R90[t-1]) - \underset{(6.3)}{0.45}*DUM78\text{–}86$$

$RB2 = 0.90$ $SEE = 0.03$ $RHO = 0.6$ $DW = 1.1$

fitted values generated by a very simple estimated money-demand equation.[4] However, the two subperiods in which these explanatory variables fail to explain the profile of real M1 correspond to two larger-than-usual waves of financial innovation. Figure 1 shows both the first wave of financial innovation during the 1978–86 period and the second wave, which began around 1993 and still seems to be in effect. In addition to using different econometric estimates to identify these subperiods, we also look at bank-by-bank data for various types of accounts in order to isolate rapid changes related to various innovations (e.g., the emergence of new types of deposits). A detailed presentation of the methodology used to calculate the magnitude of these shifts is presented in the appendix to this paper.

Typical money-demand equations cannot explain the profile of M1 over these two episodes because the explanatory variables used in this type of equation (real GDP, 90-day commercial paper rate [R90], and the consumer price index [CPI]) do not capture well the volume of transactions, the aggregate price attached to them, and the financial incentives offered by the new types of deposits. Better explanatory variables would significantly reduce the level of instability.[5] This question will be addressed in section 3.

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[4] Unless specified differently, the charts presented in this paper refer to the logarithm of real balances (using CPI as a deflator), often divided by their 1968 values.

Currency, which represents about 35 per cent of M1, was relatively unaffected by the waves of innovation illustrated in Figure 2. Innovation has certainly affected the level of currency held outside banks (see our appendix for estimates), but it seems that the impact was relatively gradual and much less obvious than the impact on demand deposits.[6] In section 2 we show that the relationship between currency and prices was more stable over time than that of M1. The remainder of section 1 focuses on demand deposits.

1.1 The first wave: 1978 to 1986

In the 1970s, a substantial amount of research showed that there was a fairly stable relationship between a narrow measure of money (M1) and total spending.[7] Furthermore, the demand for M1 seemed to be linked to an interest rate variable by a relatively large and well-determined coefficient, thus facilitating the control of money growth by means of an interest rate instrument. In late 1975 the Bank of Canada announced a specific target range for the growth of M1. The Bank hoped that this quantitative information about the orientation of monetary policy would influence economic decisions throughout the economy in a way that would minimize any disruption involved in reducing the rate of inflation.

At the same time, however, the pace of technological change began to accelerate, chartered and near-banks became more similar and grew more competitive, and, in a high-inflation environment, interest rates were high and volatile. This combination of factors led to a wave of financial innovation and, specifically, the development of new deposit products.[8]

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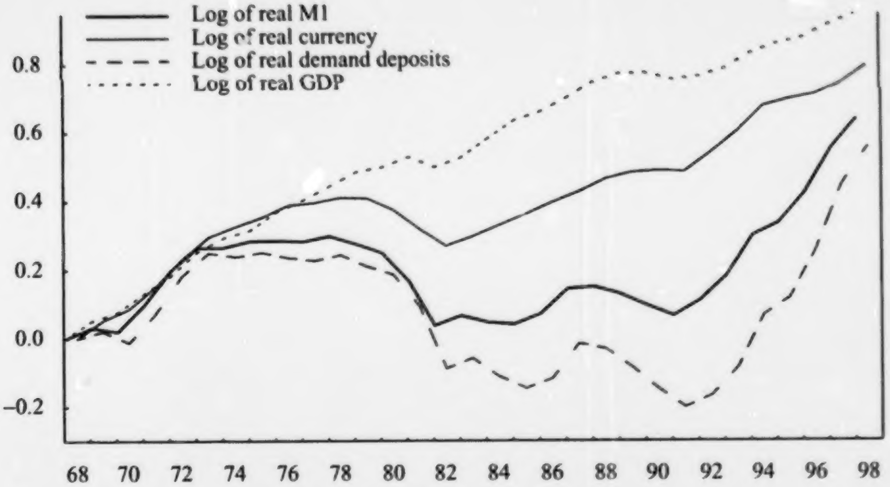
[5] For instance, is the profile of transactions money used for purchasing financial assets well captured by the pattern of real GDP? Can we generate interest rate variables that would better capture the evolution of the return attached to various demand and notice deposits? Can we create variables that would reflect various features of transactions deposits (such as accessibility, attached lines of credit, and air-miles points).

[6] The use of alternative means of payment (e.g., credit cards and debit cards), the availability of automated teller machines, and the possibility of better optimizing holdings of liquidity with the emergence of deposits paying daily interest (compared to what was possible with deposits paying interest only on the minimum monthly balance) resulted in a reduction of currency held outside banks. On the other hand, the introduction of $1 and $2 coins and, perhaps, some growth in the underground economy (see Laflèche 1994) have resulted in greater use of currency over the last decade. Our appendix presents estimates of the impact of these innovations in the 1978–86 and 1993–98 periods.

[7] See Clinton (1973) and White (1976).

[8] The historical account of the institutional developments over this period is based primarily on Freedman (1983).

Figure 2
Currency versus demand deposits



Note: Variables were divided by their 1968 value.

The impact of these innovations on both the household and business sectors is outlined below.

1.1.1 The household sector

The daily-interest savings account (DISA), introduced in 1979, was classified as a personal non-chequable notice account and thus was excluded from M1. Before this time, the standard household savings account paid interest on the basis of the minimum balance held in the account over the calendar month. The interest on DISAs was calculated on the daily closing balance, thus offering small savers the opportunity to earn near-market rates of interest on liquid assets held even for short periods of time. This change was a strong financial incentive to depositors to differently optimize their holdings of short-term liquidity. The attractiveness of this new type of account was also increased by the fact that nominal interest rates were seen as being high. Not surprisingly, these accounts proved to be very popular, and funds from traditional deposit accounts were rapidly transferred into DISAs. Although most funds were shifted from other savings products, a small part reflected reduced use of personal chequing accounts, and hence the decline in M1.

The technology that enabled financial institutions to offer such accounts also enabled a number of near-banks to offer daily-interest chequing accounts (DICAs), which were also classified as notice deposits outside M1. They included features of both the daily-interest savings account and the personal chequing account. Competitive pressures led to a gradual spread of this "all-in-one" account: Major chartered banks offered this option to their clients in late 1981 and early 1982. Typically this account offered a rate of return just under the rate on daily-interest savings accounts on daily closing balances above some minimum balance (e.g., $1,000 or $2,000) and a much lower rate on daily closing balances below the minimum. These accounts became quite popular with the public, and as a result households transferred funds from demand accounts (which are included in M1) to these new chequable notice accounts.[9]

Figures 3, 4, and 5 illustrate the substantial transfer of household funds to these new accounts. The popularity of these accounts was immediate. From 1978 to 1986, we estimate that personal notice deposits (chequable and non-chequable) increased by about $13 billion (19 per cent) above a value extrapolated from their past trend. Of this amount, $2.5 billion was money that was transferred from personal chequing accounts (classified as demand deposits) into DISAs and DICAs. Note that fluctuations in short-term interest rates do not explain such transfers of funds. In fact, in both 1978 and 1986, the R90 was at the same average level of 9 per cent.

1.1.2 The business sector

In the mid-1970s, a combination of technological developments, competitive pressures in the banking sector, and the high opportunity cost of holding non-interest-bearing balances led to the introduction of "cash-management packages" in Canada. Initially these packages were only offered to large corporations and government organizations, but by the early 1980s similar schemes were being offered to intermediate-sized companies as well. The features of these packages varied across the banking sector. In some cases the banks paid interest on current accounts at a rate tied to the prime lending rate, while other accounts delivered implicit interest in the form of foregone service charges. Balances intended to be held overnight were often transferred into non-personal notice deposits, while balances available for more than one day were invested in short-term deposits. Figures 6 and 7 illustrate the shift from current accounts into non-personal notice accounts, mostly chequable notice deposits. We estimate this transfer of funds was in the order of $9 billion (61 per cent of current accounts and 18 per cent of M1) over the 1978–86 period.

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[9] Funds from other chequable and non-chequable notice accounts were also transferred into DICAs.

Figure 3
Personal demand deposits

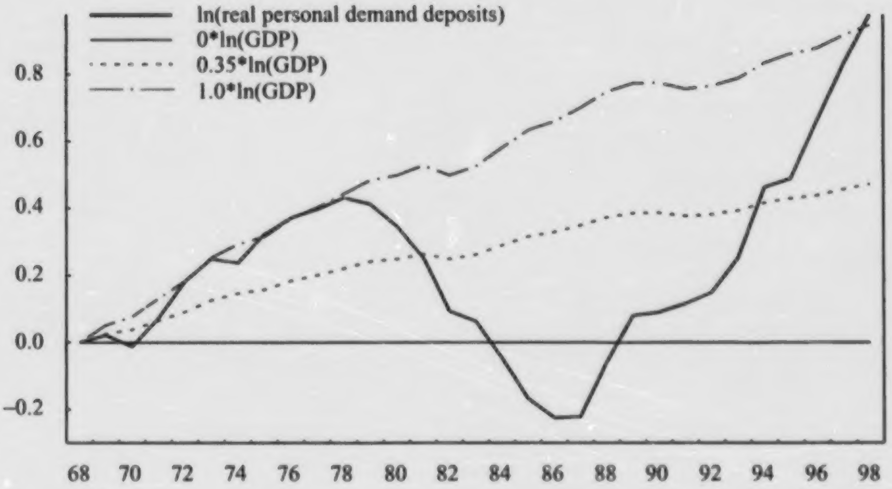


Figure 4
Personal non-chequable notice deposits

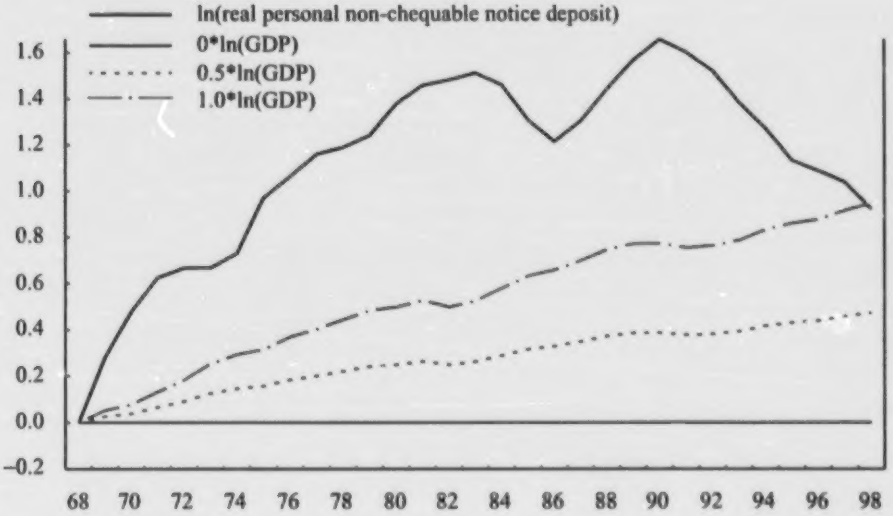


Figure 5
Personal chequable notice deposits

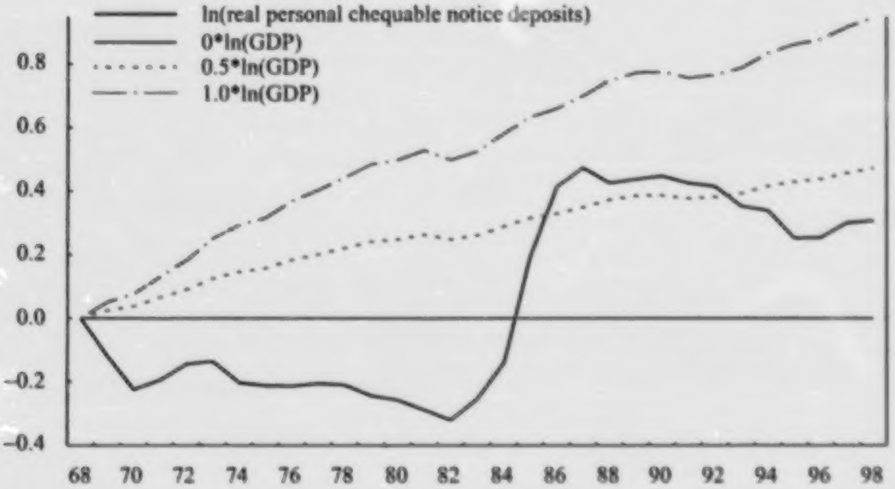


Figure 6
Current accounts

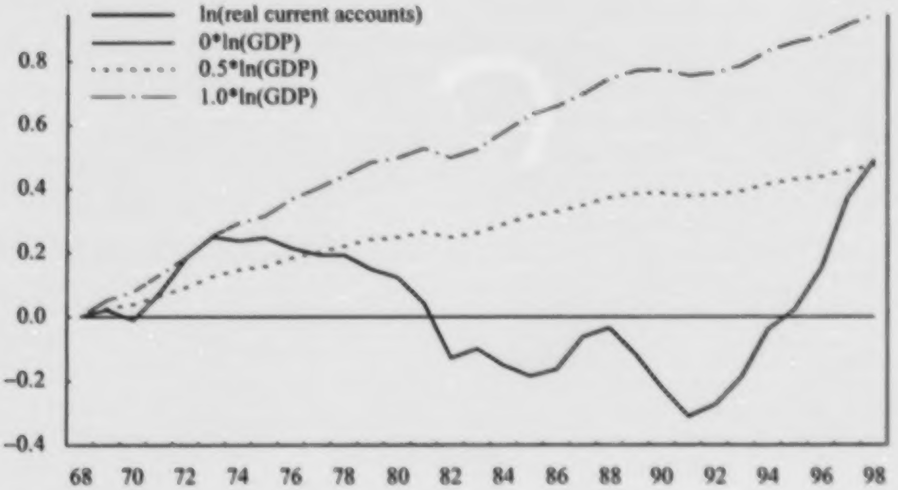
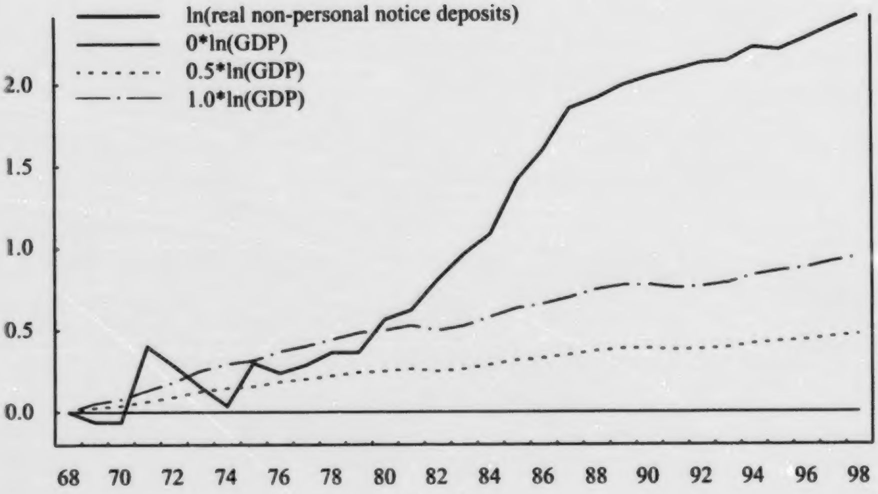


Figure 7
Non-personal notice deposits



Cash-management packages allowed corporations to reduce their levels of working balances by consolidating funds into a single account. The use of techniques such as pre-authorized account withdrawals and payroll service plans further helped businesses reduce their operational balances in non-interest-bearing demand accounts. As can be seen in Figure 6, the development of these packages significantly influenced the demand for current account balances and, hence, M1.

1.1.3 Searching for better measures of transactions balances

Over the 1978–86 period the combined effect of these financial innovations on the household and business sectors was a gradual reduction in the level of real M1 of approximately 30 per cent ($14 billion).[10] This significant shift was so difficult to interpret in the early stages that, by November 1982, the Bank of Canada formally announced it would no longer explicitly target M1.

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[10] Almost all the empirical studies demonstrate a significant shift in the demand for M1. However, there is quite a large variance in the estimated size of the shifts in these studies. The estimates are highly affected by the specifications, the estimation techniques, the data frequencies, and by the various ways of defining the dummy (e.g., a gradual shift from 1978 to 1981, as in Hendry [1995], versus a gradual shift from 1978 to 1986, as in the equation presented in Figure 1). Hendry's estimates presented in 1995 suggest that the first wave caused a downward shift in M1 of approximately 10 to 15 per cent, while the simple equation presented at the bottom of Figure 1 results in an estimate of 45 per cent.

In search of an alternative measure of transactions money, the Bank of Canada turned to M1A, which is the sum of M1 and daily-interest chequing accounts and non-personal notice deposits. M1A internalized the shift between personal demand accounts and DICAs. From 1980 until 1982 the behaviour of M1A appeared to fairly well reflect its historical relationship with total spending. However, Figure 8 shows that, after mid-1983, M1A began to grow more rapidly than could be explained by usual relationships, as chartered banks began to offer rates on the higher balances of DICAs that were comparable to short fixed-term deposits. People began to transfer money from traditional savings instruments into DICAs. As a result, M1A evolved in such a way that a large component was held for savings, rather than transactions, purposes.[11]

1.2 The second wave: 1993 to the present

By the mid- to late 1980s the pace of innovation affecting transactions balances slowed. Despite the effects of the first wave on the demand for M1, research at the Bank of Canada showed that M1 had again become a good indicator of output and inflation, perhaps because it captured a new stable pattern of transactions balances.[12] In 1995, Hendry found a stable, unique, long-run money-demand function for M1 over the sample period 1956 to 1993. In order to find this stable relationship, however, Hendry had to account for the financial innovation in the 1978–81 period with a dummy variable. His paper eventually became the basis for the development of an internal forecasting model that appeared to provide a promising predictor of inflation up to eight quarters ahead.[13]

However, shortly following the development of this forecasting model, the parameters of the model became unstable. A combination of economic factors and financial deregulation had once again set the stage for a second wave of financial innovation resulting in a shift in the demand for M1. In this second episode, depositors respond to the introduction of a large set of new features attached to standard types of deposit accounts and to a greater access to various types of investments. Nevertheless, both episodes are characterized by changes in the way depositors use their deposit accounts. The effects of this most recent episode on the household and the business sectors are outlined below.

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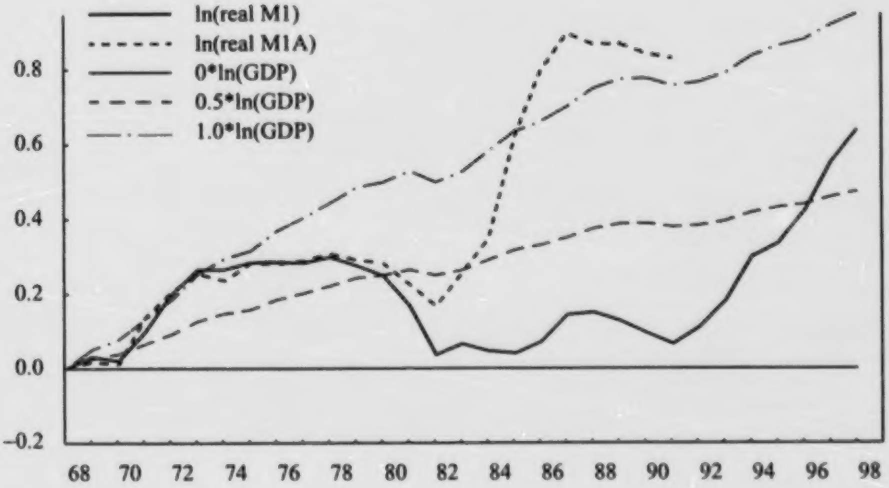
[11] For a short time, M1A seemed to be a promising alternative to M1 because it exhibited a closer relationship to output and prices. In the end, the shift in M1A turned out to be significantly larger than the shift in M1.

[12] See Poloz (1990).

[13] For more detailed information about how this model is used in developing monetary policy advice, see Adam and Hendry (2000) and Engert, Fung, Nott, and Selody (1999).

Figure 8
M1 and M1A



1.2.1 The household sector

One of the reasons that tiered DICAs became so popular as a savings vehicle was their competitive rates of return. After 1990, however, interest rates were on a declining trend. The return on balances held in personal chequable notice accounts fell to about 0.5 per cent, barely more than non-interest-bearing demand accounts. In search of higher yields, households began to move their funds out of deposits and into bond mutual funds as well as equity and mortgage mutual funds.[14] Although mutual funds existed before 1990, low interest rates stimulated demand for them in the 1990s, and banks aided the shift of savings into them by offering these funds over their counters. Savings were transferred from term deposit accounts and notice deposit accounts. It seems that transactions balances held in chequable notice accounts (outside M1) were relatively unaffected by this movement, implying that these accounts were being used increasingly as a household's primary transactions account. To further complicate matters, personal demand deposits—accounts that traditionally represented household transactions mainly to purchase goods and services—have evolved to become more closely tied to savings decisions. In 1987, changes to federal and provincial legislation allowed chartered banks to enter into the securities industry through subsidiaries. By 1988, the six major chartered banks had either created or acquired investment dealer subsidiaries. These dealers have on their balance sheets cash or margin accounts that maintain idle balances, otherwise known as free credit balances, intended for buying financial assets. In the late 1980s, the Bank decided to consolidate the balance sheets of the banks and their subsidiaries. As a result, the demand deposits arising from the inclusion of customer credit balances, which are available on demand from a dealer, were added to the personal demand deposit series and hence included in M1.[15] The argument for this was that there was virtually no difference in accounts characteristics between a credit-balance account at an investment dealer and an account at a bank. There is, however, a difference in the intended use of the money.

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[14] Other possible factors for the popularity of mutual funds may have been their increased accessibility, especially with the growing involvement of the chartered banks and the heightened sophistication of the household investor. For more on these developments, see Engert, Fung, Nott, and Selody (1999).

Figure 9 presents the level of free credit balances as a proportion of the total personal demand-deposit series. In a very short time, free credit balances grew to account for approximately half of the personal-demand-deposit series. Free credit balances increased by approximately $6 billion, an 89 per cent increase in personal demand deposits, from 1993 to 1998.[16] The rapid growth of personal demand deposits during the second wave is illustrated in Figure 3. Currently, a large proportion of the monthly fluctuation in personal demand deposits is related to changes in the level of free credit balances.

Although both are maintained for transactions purposes, demand deposits at chartered banks are held primarily for the purpose of buying goods and services, while free credit balances are held for buying financial assets. The rapid increase in the latter in the 1990s reflects the enormous popularity of mutual funds. Both of these accounts represent transactions money. However, free credit balances, money most likely held for the purpose of buying financial assets such as mutual funds, ultimately represent a portion of household savings, and fluctuations represent changes in future, as opposed to current, spending plans. Free credit balances account for only 8 per cent of M1, but it is a highly volatile component used mainly to manage savings rather than to transact for goods and services.[17] The existence of money held for different purposes may imply the need to have a

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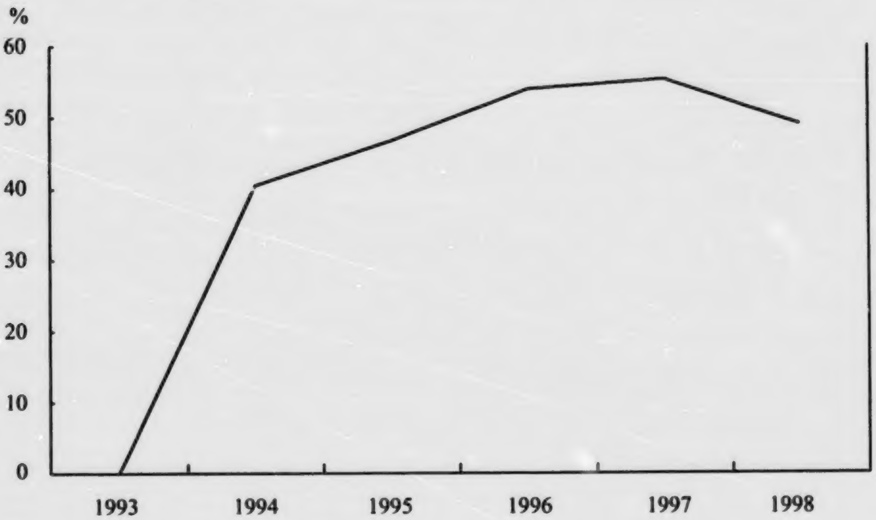
[15] Approximately 90 per cent of balances in retail investment accounts are held by individuals. Free credit balances held by the business sector are consolidated into the non-personal-demand-deposit series.

[16] Free credit balances form only 2.5 per cent of the current $300 billion stock of mutual funds.

[17] Section 3 further explains the importance of distinguishing between money used to buy financial assets and money used to buy goods and services.

Figure 9
Free credit balances as a percentage of total personal demand deposits, annual series



broader set of variables (in addition to GDP, CPI, and R90) to explain the profile of these two types of balances.

Despite the important changes affecting the deposit accounts held by households, most of the instability in the demand for M1 in the 1990s appears to be more closely related to innovation in business accounts, which is the subject of the next section.[18]

1.2.2 The business sector

In the early 1990s, the market for small business funds became very competitive, and some banks began to pay interest on business accounts. One of the reasons the market became so competitive was that banks wanted to improve their relationships with small businesses. In 1994–95, banks developed marketing strategies, on both the asset and the liability sides, geared toward small businesses. Each bank's approach was slightly different. Some banks reduced fees on non-interest-bearing accounts, while others began to offer interest on their demand and notice accounts. Banks that already offered interest on their accounts introduced an attractive tier structure, with the top tier rivalling most short-term cash-management instruments. The bottom line for the aggregate deposit market was that these innovations encouraged small businesses to hold their extra cash balances in deposit accounts. In other words, these new features encouraged some firms to put a larger portion of their liquidity into demand deposits and to begin using these accounts for temporary savings as well as for transactions purposes.

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[18] Nevertheless, it is important to understand how household usage patterns have evolved to ensure that empirical measures best match theoretical concepts of transactions money.

Another factor that affected the business sector was the elimination of differential reserve requirements on demand and notice deposits in the early 1990s, removing the incentive for banks to distinguish between demand and notice accounts.[19] There being virtually no distinction between these accounts, except for a withdrawal-notice requirement that is essentially irrelevant, bank classification of deposit accounts has become increasingly arbitrary. Some banks have chosen to classify new business accounts as current accounts and have pursued marketing strategies aimed at moving existing notice-account holders into current accounts by offering a better fee or interest rate structure on these demand-deposit accounts, leading to a shift from notice to current accounts. M1 growth was boosted temporarily. Figure 6 illustrates the large increase in current accounts that has occurred since 1993. We estimate that approximately $17.4 billion was transferred into current accounts between 1993 and 1998, an amount that translates into increases of approximately 80 per cent in the level of current accounts and 31 per cent in M1. Over this period, the use of non-personal chequable notice deposits also increased more than expected ($7.3 billion, or 29 per cent), while non-personal non-chequable deposits declined (–$1.4 billion, or –29 per cent).

Nevertheless, with both non-personal demand and chequable notice deposits now being used for transactions purposes, the classification distinction between demand and notice deposits makes little sense. Regardless of whether a firm's operating account is classified as a demand or a notice deposit, all account holders must give 24 hours' notice before withdrawing large sums of funds.[20] Therefore, by not including chequable notice accounts in our measure of narrow money, we are not adequately capturing the transactions balances of the business sector.[21]

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[19] The phase-out of reserve requirements began in June 1992 and was completed by June 1994. Prior to the phase-out, reserve requirements on demand and notice deposits were 10 per cent and 3 per cent respectively. These requirements were imposed on the chartered banks, but not on other deposit-taking institutions.

[20] A large sum of funds is considered at most institutions to be $10 million or more.

[21] Moreover, given that these deposits are primarily held for operational purposes, they are the closest series, next to currency, to represent money's medium-of-exchange role. Consequently, some have argued for the use of a purely business aggregate to represent transactions money.

1.2.3 Searching for better measures of transactions balances

Our estimates suggest that the combined effects of financial innovation in the second wave caused the level of real M1 to shift by up to 45 per cent.[22] In light of these developments the Bank of Canada has begun to publish two alternative narrow-money aggregates: M1+, which is the sum of M1 and chequable notice deposits; and M1++, which is the sum of M1 and all notice deposits.[23] Although these alternative aggregates internalize the substitutions between demand and notice deposits, they also include deposits that are held primarily for savings purposes. Thus, movements in the demand for these aggregates may reflect changes in savings behaviour, as well as transactions intentions. For example, the faster growth of M1+ reflects mainly the net transfer of liquidity (about $25 billion) by the business sector from other sources into current accounts and non-personal chequable notice deposits. On the other hand, the slower growth in M1++ reflects the net shift from personal deposits to mutual funds (about $30 billion), outweighing the transfer of business liquidity into demand and notice deposits. The relationship between the level of these alternative aggregates and the level of output still appears to be distorted even if some of the transfer of funds discussed above is internalized (Figures 10[24] and 11).[25]

2 Empirical Implications of Financial Innovation

Although it is important to understand how financial innovations affect the nature of deposit products, policy-makers ultimately need to understand how these innovations affect aggregate measures of money and their empirical models. This section illustrates how the financial innovations described in section 1 have affected the correlation between narrow money, output, and prices.

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[22] In contrast, simulations performed with Hendry's vector-error-correction model (VECM) suggest that the shift in M1 would be in the order of 25 per cent. See Adam and Hendry (2000).

[23] Unlike M1, which includes data from only the Canadian chartered banks, M1+ and M1++ include data from credit unions and caisses populaires, as well as trust and mortgage companies, in order to reflect the similarities and substitutability of deposit accounts at chartered banks and near-banks.

[24] In Figure 10, the very rapid growth of M1+ over the 1984–86 period reflects the transfer of funds from savings and fixed-term deposits to DICAs during the first wave of innovation.

[25] The more financial instruments are included in a monetary aggregate, the more stable is the aggregate's behaviour. This makes sense given that broader aggregates more closely represent savings behaviour. For further information on the relationship between broader aggregates and inflation, see McPhail (2000).

Figure 10: M1+

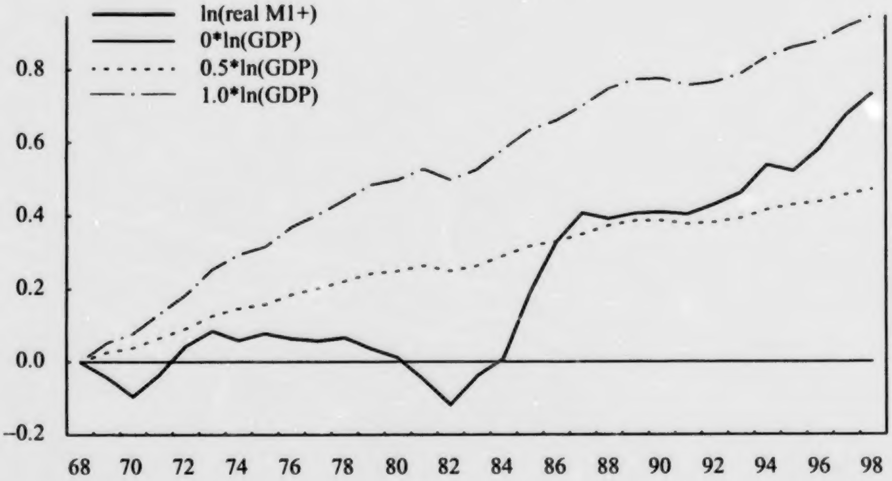
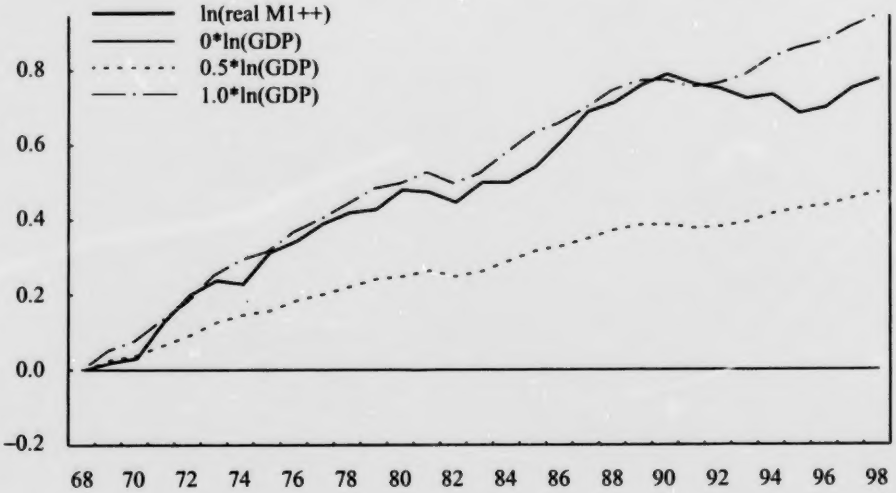


Figure 11: M1++



2.1 Data and methodology

It is well known that the correlation between money growth and inflation is relatively strong over a long horizon, while a relation between money and output growth may be observable over a much shorter period. Research at the Bank (see Muller 1990; Armour, Engert, and Fung 1996; and Fung and Kasumovich 1998) has shown that the effect of a monetary policy shock on prices reaches its peak after two or three years, while the impact of an output shock is more rapid and can peak after only a few quarters—as early as two or three quarters. Therefore, for the purposes of this exercise, the correlation coefficients for money and prices will be estimated using annual data, whereas those for money and output will be estimated using quarterly data.

Table 1 lists the money aggregates used in this correlation exercise. Since currency almost always represents transactions money, it was chosen to act as an empirical check on the economic theory. M1, M1+, M1++, and M2++ were chosen to see how the waves of financial innovation have affected the Bank's published aggregates. The transactions aggregates TA1 to TA4 were constructed to account for some of the other possible combinations of financial instruments that may better represent transactions money. TA1 and TA2 may better capture transactions money than TA3 and TA4, given that business deposits are primarily held for operational purposes while money held in personal deposits may be used for either transactions or savings. Finally, in order to illustrate the difference between the behaviour of transactions and savings aggregates, as well as between personal and business aggregates, the remaining aggregates (personal M1++, business M1++, and personal savings) were also considered.

2.2 The correlation between money and prices

Table 2 presents the correlation coefficients between the rate of growth of the 12 selected monetary aggregates and the rate of growth of the CPI over the 1969–98 period. We present the correlation coefficients between the selected monetary aggregates and various leads and lags of inflation. In so doing, one can identify whether money is a leading or lagging indicator of future inflation. The time series plotted in Figure 12 illustrate the profile of inflation and money growth relative to their respective means over the 1969–98 period.

As Table 2 shows, aggregates affected significantly by the two waves of financial innovation are found to have weak correlations with inflation. These include M1, M1+, and transactions aggregates TA1 to TA4. However, currency and aggregates that internalize shifts between demand and notice deposits (M1++, personal savings, and M2++) are found to be highly correlated with inflation. These observations support the notion that money is a leading indicator of inflation, even though they include money held for purposes other than transactions. These results (especially the case of currency) lead us to believe that a measure of transactions money that is adequately corrected for shifts due to financial innovation would have done very well in predicting inflation throughout the entire sample period.

Table 1
Concepts and definitions

Monetary aggregates and their main components

Currency (CURR)
Personal chequing accounts (PCAs) (include free credit balances [FCBs])
Current accounts (CAs)
Gross M1
Personal and non-personal chequable notice accounts
M1+
Personal and non-personal non-chequable notice accounts
M1++
Personal fixed-term deposits, Canada Saving Bonds, mutual funds
M2++

Splitting balances between the personal sector and the business sector

Personal M1++ = PCA + personal notice deposits
Business M1++ = CURR + CA + non-personal notice deposits
(We assume that all of CURR [in fact, it is about 80 per cent] is held by the corporate sector.)

Personal savings

Personal savings accounts = FCB, personal non-chequable notice deposit, and (M2++ – M1++)

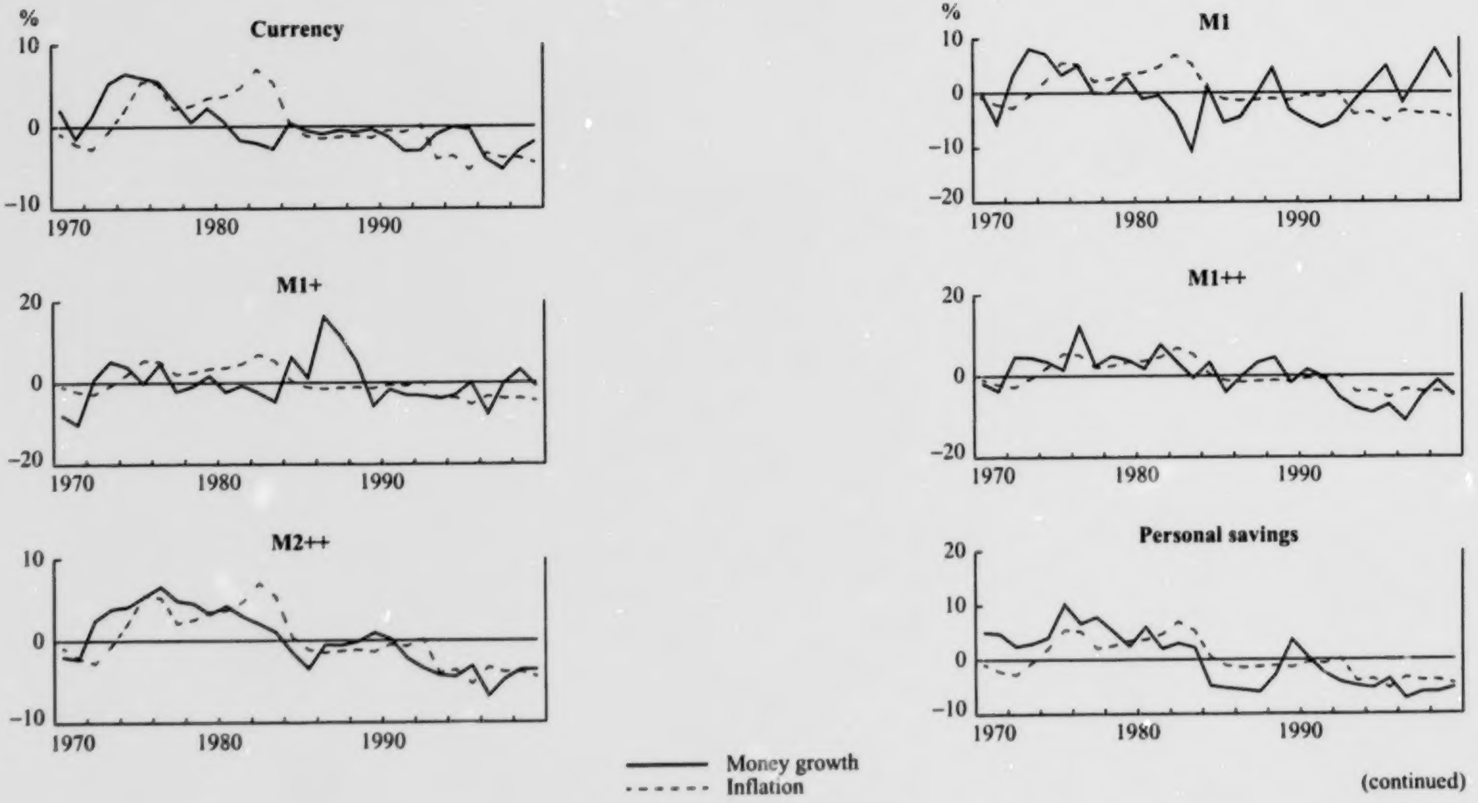
Additional transactions measures

TA1 = currency + current accounts
TA2 = TA1 + non-personal chequable notice deposits
TA3 = TA2 + personal chequing accounts (less free credit balances)
TA4 = TA3 + personal chequable notice deposits

Table 2
Correlation coefficients: Money growth versus inflation, 1969 to 1998, annual frequency

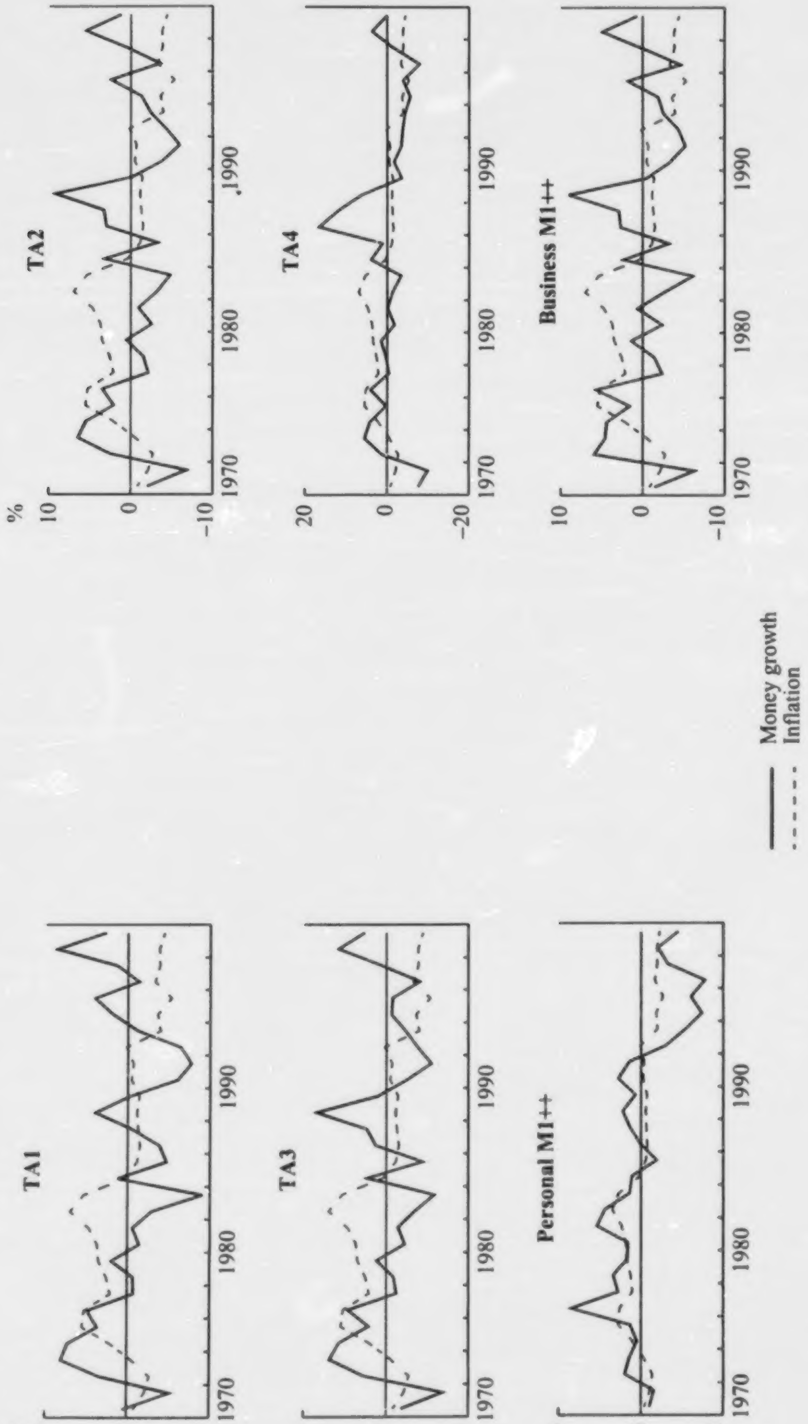
Rate of growth of money (*t*)	**Inflation rate (CPI)**						
	***t*–3**	***t*–2**	***t*–1**	***t***	***t*+1**	***t*+2**	***t*+3**
Currency	0.09	0.19	0.30	0.41	0.56	0.66	0.67
M1	–0.42	–0.36	–0.29	–0.16	0.12	0.40	0.48
M1+	0.24	0.05	0.00	0.01	0.10	0.18	0.17
M1++	0.30	0.43	0.59	0.67	0.73	0.74	0.65
M2++	0.29	0.44	0.63	0.77	0.86	0.88	0.80
Personal M1++	0.35	0.51	0.70	0.76	0.74	0.66	0.56
Business M1++	–0.21	–0.21	–0.14	–0.08	0.13	0.34	0.40
Personal savings	0.60	0.35	0.58	0.71	0.76	0.76	0.73
TA1	–0.41	–0.34	–0.28	–0.15	0.11	0.40	0.48
TA2	–0.24	–0.26	–0.20	–0.12	–0.07	0.28	0.32
TA3	–0.33	–0.27	–0.20	–0.09	0.12	0.37	0.41
TA4	0.25	0.09	0.08	0.10	0.20	0.28	0.25

Figure 12
Money growth versus inflation, deviation from mean growth, annual data



(continued)

Figure 12 (continued)
Money growth versus inflation, deviation from mean growth, annual data



As noted in section 1, aggregates such as M1 and M1+ were subject to dramatic shifts over the 1969–98 period. As a result the long-term relationship between money and inflation has been clouded. This seems to be especially true for M1 in the 1990s (see Figure 12). During a time when the rate of inflation was falling (from 5 per cent to 1.5 per cent), M1 was growing at rates between 15 and 20 per cent. By obscuring the relationship between money and prices, financial innovations have made it more difficult to interpret the information content of M1 for inflation. This simple exercise suggests that during a wave of financial innovation, broader aggregates that internalize the implied shifts, such as and M1++ and M2++, may be more useful leading indicators of price movement.

2.3 The correlation between money and output

Tables 3 and 4 present the correlation coefficients between various real money aggregates and output over the 1969–98 period as well as over the 1990–98 period. The time series presented in Figure 13 illustrate the profile of real GDP and real money growth relative to their respective means over the 1990–98 period.

Tables 3 and 4 show that all narrow aggregates, including those that were significantly affected by financial innovations, are found to be highly correlated with output. This continues to hold for the 1990s. Our results suggest that the financial innovations that affected the trend growth rate of many narrow aggregates did not significantly affect the profile of the short-term growth deviations around its mean. This implies that narrow aggregates have continued to be informative leading indicators of the cyclical movement of output. Such an outcome is certainly possible: Consider the case where a series of shocks significantly affect the trend profile of a chronological series while its seasonal pattern is largely unaffected.

These correlation coefficients are calculated ex post. Unfortunately, policy-makers rarely have the information necessary to contemporaneously identify and evaluate the impact of a financial innovation on the future trend of a monetary aggregate. Therefore, even though there appears to be a strong correlation between narrow aggregates and output, a good deal of judgment is needed to use these aggregates as leading indicators of future output. Recent work at the Bank of Canada on indicator models for output, using narrow-money aggregates, supports this conclusion.

3 Where Do We Go from Here?

When the first wave of financial innovation occurred, the Bank was explicitly targeting M1. In order to properly determine the appropriate

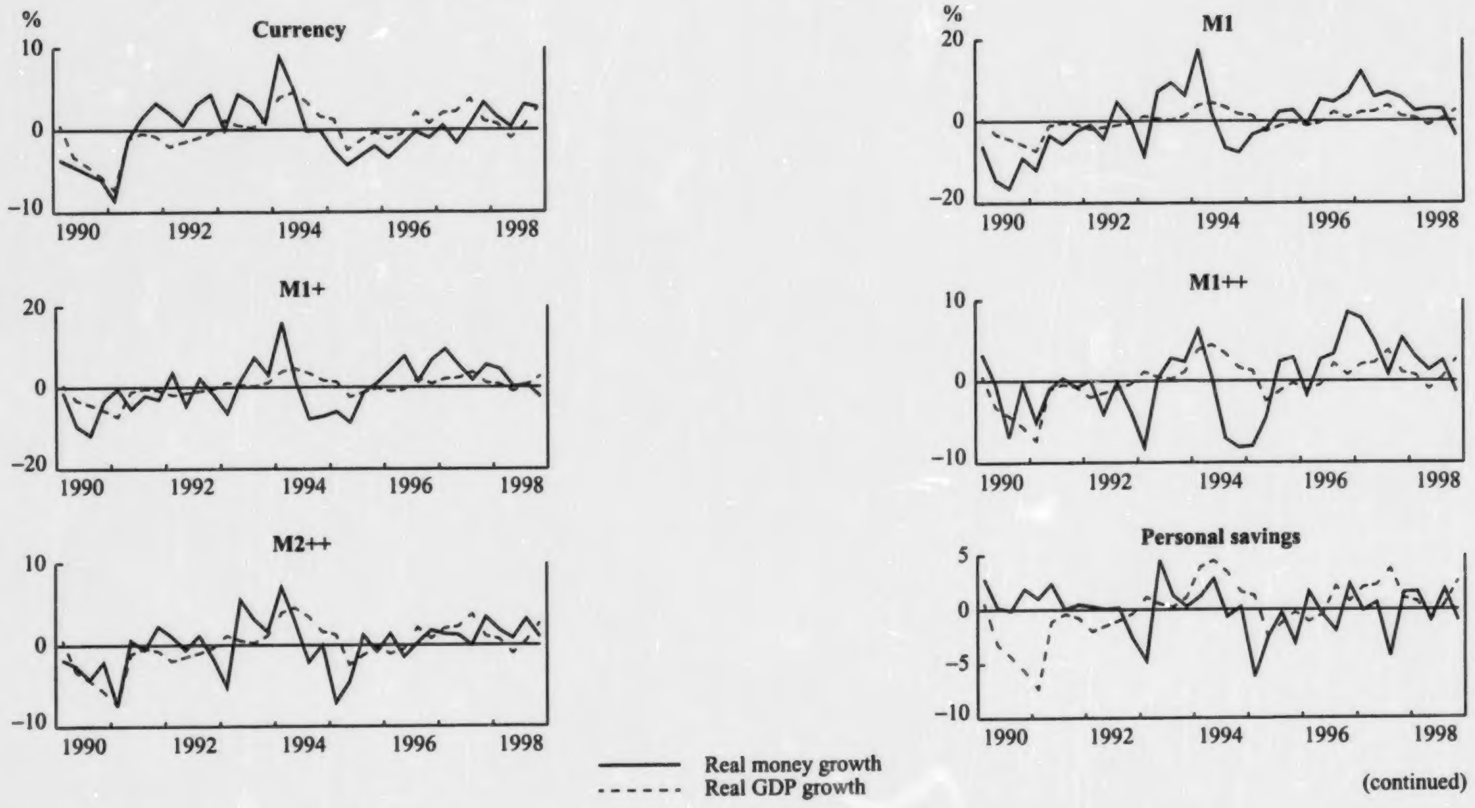
Table 3
Correlation coefficients: Real money growth versus real GDP growth, quarterly frequency, 1969Q1–1998Q4

Rate of growth of money (*t*)	Real GDP growth								
	t–4	*t*–3	*t*–2	*t*–1	*t*	*t*+1	*t*+2	*t*+3	*t*+4
Currency	0.03	0.14	0.29	0.43	0.55	0.63	0.63	0.58	0.50
M1	–0.09	–0.02	0.10	0.27	0.44	0.57	0.61	0.54	0.43
M1+	–0.01	0.01	0.08	0.20	0.35	0.47	0.50	0.44	0.33
M1++	0.12	0.06	0.09	0.20	0.35	0.50	0.54	0.50	0.38
M2++	0.26	0.34	0.44	0.51	0.58	0.62	0.59	0.51	0.42
Personal deposits	0.18	0.11	0.09	0.11	0.18	0.24	0.25	0.21	0.12
Business deposits	–0.11	–0.05	0.08	0.26	0.46	0.59	0.61	0.54	0.42
Personal savings	0.38	0.49	0.56	0.56	0.52	0.45	0.37	0.30	0.24
TA1	–0.09	0.00	0.14	0.31	0.47	0.59	0.61	0.54	0.44
TA2	–0.09	–0.04	0.07	0.23	0.41	0.56	0.61	0.55	0.44
TA3	–0.08	–0.04	0.07	0.22	0.40	0.56	0.61	0.55	0.44
TA4	0.05	0.08	0.14	0.24	0.37	0.47	0.49	0.43	0.32

Table 4
Correlation coefficients: Money growth versus real GDP growth, quarterly frequency, 1990Q1–1998Q4

Rate of growth of money (*t*)	Real GDP growth								
	t–4	*t*–3	*t*–2	*t*–1	*t*	*t*+1	*t*+2	*t*+3	*t*+4
Currency	0.17	0.06	0.30	0.51	0.65	0.69	0.64	0.53	0.38
M1	0.21	0.34	0.48	0.63	0.78	0.87	0.91	0.84	0.65
M1+	–0.01	0.07	0.21	0.39	0.58	0.75	0.84	0.79	0.58
M1++	0.00	0.03	0.11	0.23	0.39	0.53	0.62	0.58	0.41
M2++	–0.08	0.08	0.28	0.48	0.66	0.78	0.80	0.70	0.49
Personal deposits	–0.13	–0.20	–0.19	–0.10	0.04	0.19	0.29	0.28	0.16
Business deposits	–0.09	0.25	0.43	0.61	0.77	0.87	0.89	0.77	0.55
Personal savings	–0.10	0.06	0.26	0.48	0.65	0.75	0.72	0.57	0.33
TA1	0.19	0.36	0.54	0.71	0.84	0.90	0.90	0.79	0.59
TA2	0.14	0.29	0.47	0.65	0.80	0.89	0.90	0.78	0.55
TA3	0.09	0.20	0.34	0.48	0.62	0.74	0.81	0.78	0.65
TA4	0.00	0.08	0.21	0.35	0.51	0.62	0.68	0.63	0.46

Figure 13
Real money growth versus real output growth, deviation from mean growth, quarterly data



Currency

M1

M1+

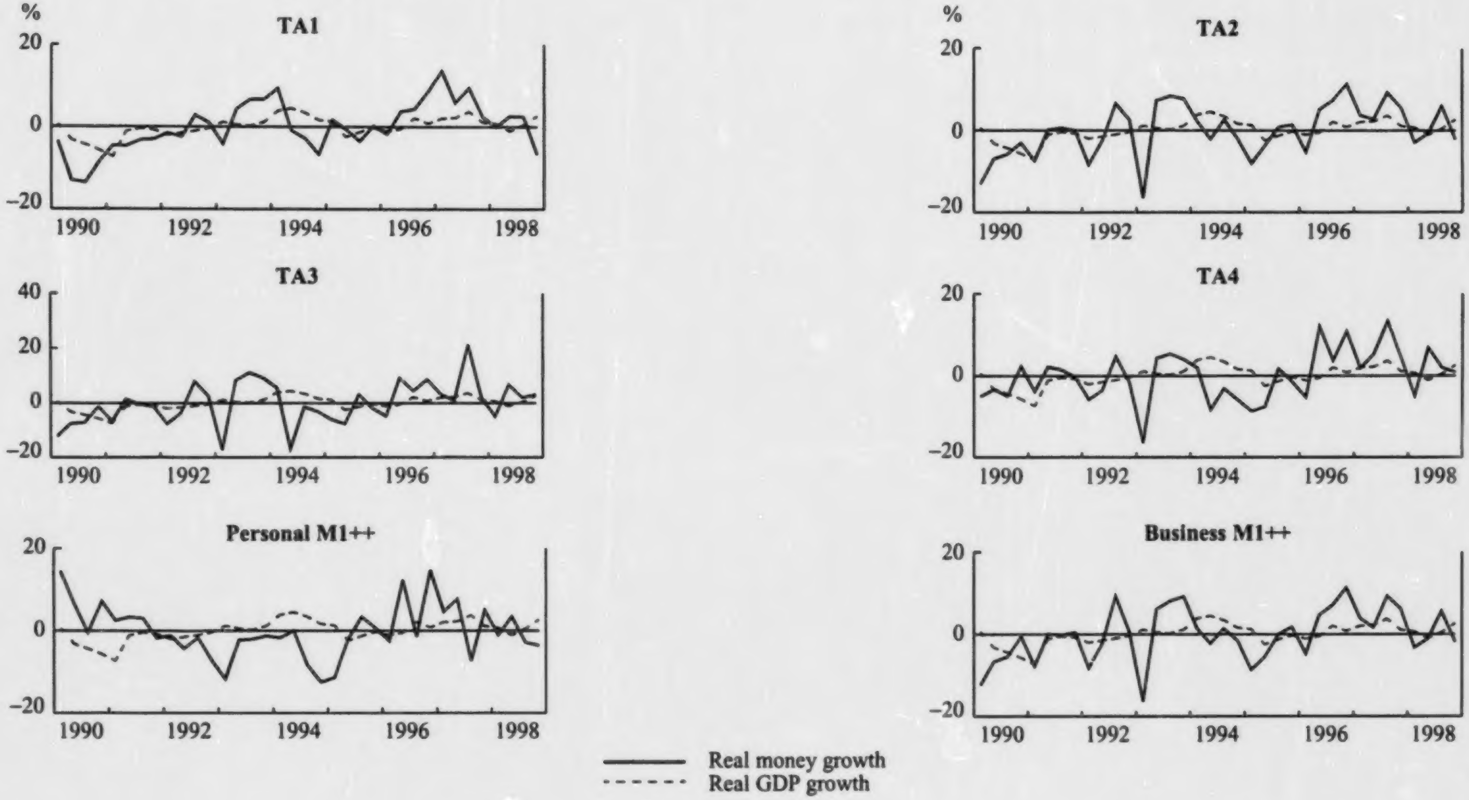
M1++

M2++

Personal savings

(continued)

Figure 13 (continued)
Real money growth versus real output growth, deviation from mean growth, quarterly data



interest rate response when M1 deviates from its target range, the Bank requires a tight and stable relationship between M1, output, and prices.[26] After it abandoned monetary targeting, the Bank searched for a new monetary aggregate that demonstrates a stable relationship with total spending and interest rates. The first candidate was M1A, which initially showed promise but shortly after its development was also affected by financial innovation.

As a result, the Bank continued to pursue an alternative aggregate that could be used as a guide for policy. This pursuit eventually led to the publication of a study that empirically tested and compared the properties of 46 different monetary aggregates.[27] This comprehensive examination could not identify a better aggregate than M1 as a leading indicator of output or a better aggregate than M2 or M2+ as a leading indicator of inflation. However, the Bank also concluded that instabilities, mainly originating from financial innovation, would make it too difficult to base monetary policy decisions on targets defined with these aggregates.

This past approach of identifying, redefining, and empirically testing various monetary aggregates in the face of recurring financial innovations has yielded mostly unsatisfactory results. Policy requires a stable money-demand function, but unfortunately, in a world of financial innovation it is unlikely that any single aggregate that uses fixed weights of financial instruments will exhibit a time-invariant, stable relationship with prices and income. As a result, when for a period of time a particular aggregate exhibits such a relationship, its duration and economic significance are unclear. Moreover, in an ideal world the goal of policy-makers is to find an aggregate that is based on a strong theoretical foundation (i.e., the concept of transactions money), that exhibits a stable relationship with output and prices, and that can be explained within the framework of a rigorous economic model of the transmission mechanism.[28]

Unfortunately, policy-makers now have few alternatives but to pursue this course of action despite its weaknesses. For example, as discussed in section 1, the Bank has recently published the alternative aggregates M1+ and M1++, which attempt to internalize recent shifts owing to financial innovation. Unlike past attempts, however, the development of M1+ and M1++ is not intended as a first step toward another econometric exercise designed to identify an aggregate that has a more stable relationship with output and prices. Although these alternative aggregates more closely represent transactions money today compared with other aggregates, such as M1, it is likely just a matter of time before another wave of financial innovation will occur and yield another unstable relationship. Thus, M1+ and M1++ are useful only in the limited sense that they provide extra information that can help us understand the impact of recent innovation on M1 demand. Moreover, because the Bank publishes these alternative aggregates, the general public can better appreciate the issues considered by monetary policy authorities.

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[26] As Freedman (1983) points out, in the early stages of this episode the Bank of Canada's options included rebasing the target range, redefining the targeted monetary aggregate, or simulating an artificial series.

[27] Twenty-three of them were simple-sum aggregates and 23 were divisia indexes. See Hostland, Poloz, and Storer (1988).

[28] There is also the need to be able to influence the profile of the aggregate over time by moving very short-term interest rates.

Clearly, the basket of financial instruments that is available to and desired by economic agents for the purpose of transactions evolves over time. Thus, the set of instruments that best captures transactions money today is not the same as it was yesterday, nor will it be the same tomorrow. Technology reduces operating costs and thus ensures continual financial innovation and evolution of the financial instruments used for settling transactions.[29]

From an econometric perspective the practice of adding a new component to an existing aggregate in order to reflect a recent financial innovation incorrectly presupposes that this new aggregate will be consistent with the historic deposit choices of economic agents. It is unrealistic to expect that such a practice would necessarily result in a sustained and stable money demand. Furthermore, a well-defined aggregate at any particular point in time may be empirically rejected in time-series analysis. A narrow monetary aggregate that aims to capture the money used for transactions must reflect agents' evolving choices of transaction instruments. Failing this, the cycle of redefining monetary aggregates following each wave of financial innovation will continue. As a result, empirical instability and imprecise data will be a frequent concern.

One possible approach to this issue may be to develop an aggregate that responds contemporaneously to financial innovation. This task presents a difficult technical challenge and a difficult identification problem. This challenge should be of interest to policy-makers, bankers, and academics alike. Some of the issues that must be addressed to implement such an approach are:

- Identifying and quantifying a financial innovation as it occurs contemporaneously with respect to deposit products and economic choices. The work of Pierre Siklos[30] and Feldstein and Stock (1992) are examples of research in this direction.

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[29] Consider a few examples of change that could have significant impact: e-cash, virtual banking, increased access to the payment system by a wider variety of payment intermediaries, and new types of accounts with various features to fulfill many purposes (e.g., transactions, savings, lines of credit, and air-miles points).

- Modifying the Bank's deposit classification system so that the categories better reflect the nature of financial products the banks offer for the purpose of transactions services. For example, chartered banks are still required to classify deposit products as either demand or notice accounts; however, the elimination of reserve requirements has rendered this distinction essentially irrelevant, so the classification of many deposit products has become quite arbitrary. Many accounts that are used primarily for transactions services are classified as notice accounts despite the fact that these funds are available upon demand.
- Identifying and separating the balances held in financial institutions that are used for transactions purposes, even though financial innovations continue to increasingly blur the line between transactions and savings. What are the characteristics of balances used for transactions purposes? We need better data on the turnover of the various types of deposits as well as on the link between the fluctuations of these balances and the withdrawal of cash and the use of debit and credit cards. Are free credit balances used primarily for buying and selling financial assets rather than goods and services? Is the GDP an adequate variable to explain the volume of transactions? Should we consider other volume and price measures?[31] Should we concentrate modelling efforts on the sum of these two types of transactions balances or should we try to explain each of them separately? If the Bank of Canada's inflation target is defined in terms of the CPI, should we concentrate more on balances held for transacting goods and services?
- Determining a methodology that both satisfies the necessary conditions of aggregation theory and ensures the maintenance of a continuous series despite the fact that the basket of financial instruments included in the narrow-money aggregate changes over time. For example, suppose that M1 best represents transactions money from 1986 to 1994, but from 1994 onwards, M1+ is a better representation. It is a challenge to construct a

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[30] See Bordo, Jonung, and Siklos (1993, 1997); Siklos (1993); and Raj and Siklos (1988).

[31] We need to better understand how the transmission mechanism of inflation is affected by the demand for transactions balances related to the purchase of financial assets and by the price of these assets. These studies may affect the construction of monetary aggregates, the selection of new explanatory variables, or both.

time-consistent measure of transactions money for the last 30-year period, keeping in mind that the stock of M1 is around $90 billion but the stock of M1++ is over $260 billion.[32]

The rewards to following this approach could be substantial. The benefits would not only extend to the Bank, but also to academic researchers, financial institutions, and economic forecasters. Some of the benefits to these groups are:

- **Bank of Canada:** A narrow-money aggregate that adequately captures the theoretical specification of transactions money over time would provide useful insights into current economic activity. This, in turn, would improve the formulation and the implementation of monetary policy.
- **Forecasters:** Forecasts of macroeconomic variables, such as output and inflation, would be improved by a better measure of transactions money. Governments, businesses, and the public employ these forecasts to form their expectations. For instance, forecasts of inflation affect wage negotiations, budget allocations, and interest rate forecasts. Thus, constructing a stable monetary aggregate should improve economic agents' conditional expectations.
- **Academics:** Monetary aggregates are used in a set of macro "fundamentals" that are applied in empirical studies, and monetary general-equilibrium models are calibrated from such data. The literature suggests that such models poorly replicate the nominal features of the economy. The role of problematic monetary data in these results is an important factor deserving macroeconomists' attention.
- **Financial institutions:** Many banks rely on monetary aggregate data to provide insight into both macroeconomic activity and their performance relative to other financial institutions. If the institutional data are imprecise, market-share calculations and marketing decisions are affected.

There are many benefits in assembling a monetary aggregate from a basket of financial instruments with time-varying weights, but assembling it will take time. In the interim, the challenge for policy-makers is how to use the information contained in the existing range of narrow-money aggregates. At this time, the impact of financial innovation on the demand for a particular aggregate is very difficult to assess contemporaneously. Consequently, in order to extract information from money to predict future movements in output and prices, the Bank has begun to monitor a broad range of narrow-money aggregates. In so doing, it may more easily identify shifts in the patterns of agents' use of various transactions products with each wave of innovation.

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[32] Some work is being done at the Bank by Scott Hendry and Joseph Atta-Mensah to investigate different ways of constructing and/or estimating time-variant weights that would be used to create narrow monetary aggregates that are more responsive to financial innovation.

It is possible that the ideal—a transactions aggregate that adapts contemporaneously to financial innovations—is unattainable. In the event, two alternative approaches can help policy-makers interpret narrow aggregates in the presence of financial innovation. First, placing greater emphasis on monitoring institutional developments in the banking sector might enable quicker identification of the effects of financial innovation on money demand. Second, investigating why M1 is correlated so closely with output and prices would be worthwhile. Is M1 primarily composed of business deposits? If so, it may be useful to develop and monitor a type of business aggregate.

In a world of financial innovation, no single aggregate, generated as a fixed combination of existing financial instruments, is likely to exhibit a time-invariant, stable relationship with prices and income, given that the basket of instruments used for transactions purposes evolves over time. Thus, narrow aggregates that aim to capture transactions money must be used prudently.

Given the implications of a poorly defined aggregate, much future research is needed. We need a multi-faceted program aimed at developing measures of transactions money that would react more rapidly to financial innovation. In the meantime, however, Bank economists should monitor a broad range of monetary aggregates; this enables us to follow the impact of future financial innovations on the total basket of financial instruments available for transactions services.

Appendix
Measuring Shifts in Narrow-Money Aggregates

Here we describe the methodology used to measure the two significant shifts that have affected narrow monetary aggregates and their components from 1969 to 1998. Given the role played by M1 over that period, special attention is given to this aggregate.

The data used in this exercise are the same as described in Table 1. We also select the annual frequency and use some of the estimated long-run elasticities presented in Hendry (1995). To quantify the amplitude of the two major shifts previously identified, we had to first take into account the impact of interest rates on money balances. So we tried to find a year at the beginning and end of each shift in which the interest rate was at roughly the same level. Fortunately, we were able to find such dates very close to the estimated start and end dates of the financial-innovation waves. In 1978 and in 1986 the average annual R90 value was 9 per cent.[1] Similarly, in 1993 and in 1998 the average value of R90 was 5 per cent.

For each innovation period we define the size of the shift to be the change in real balances between the beginning and end dates of the shift, minus the estimated change related to change in real GDP:

$$\ln(Shift\,/CPI)_i = \ln(M_i\,/CPI)_{end} - \ln(M_i\,/CPI)_{begin} - 0.6\,[\ln(GDP)_{end} - \ln(GDP)_{begin}],$$

where 0.6 is a long-run output elasticity generated by the M1 VECM described in Hendry (1995) and where M_i is any group of accounts listed in Table A1.[2]

This methodology is fairly crude. It assumes that the money balances are not far, on average, from their long-run equilibrium every year and that the long-run output elasticities of the balances are not too distant from each other. We assume that a full adjustment in the current period makes more sense with annual data, which we have used, than with quarterly or monthly data. We have recalculated the shifts related to financial innovation with a unitary income elasticity instead of 0.6. Such modification did not materially affect most of our estimates, and it did not alter our conclusions.

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[1] If the increase of short-term interest rates from 9 per cent to 18 per cent is used to explain the reduction of real M1 in the 1978–81 period, it cannot explain why real M1 did not accelerate over the 1982–86 period when interest rates were returning to near the 1978 level.

[2] Implicitly, we are using the following simple money-demand equation applied to annual data:

$$\ln(M/CPI) = a + b\,\ln(GDP) + c\,\mathrm{R90}.$$

We would have liked to use more sophisticated econometric techniques, but it is difficult to rely on them when there is so much instability and when the modelling of financial innovation is so poor.[3] Moreover, for this paper, we are only looking for rough estimates of the size of the major shifts.

In 1986, the level of real GDP was 24 per cent above what it was in 1978. In both these years R90 was 9 per cent. Using an income elasticity of 0.6, real M1 should have increased by about 14 per cent. However, real M1 decreased by 20 per cent. These figures imply that there was a 30 to 35 per cent downward shift in M1 over that period. Similarly, over the 1993–98 period we should have observed an increase of 9.6 per cent in real M1, given the recorded 16 per cent growth of real GDP. We recorded 57 per cent growth in real M1 over that period, implying a shift of about 40 to 45 per cent in M1.[4] Table A1 presents the estimates of the size of the shifts for various narrow aggregate components for both waves.

Table A1
Estimates of the shifts affecting the components of the narrow aggregates, billions of dollars

	First wave 1978–86		Second wave 1993–98	
Currency	–2.2	(–13%)	3.0	(+11%)
Personal chequing accounts	–2.4	(–45%)	6.4	(+89%)
Personal chequing accounts less free credit balances	–2.4	(–45%)	0.0	(0%)
Current accounts	–9.1	(–61%)	17.4	(+80%)
Gross M1	–14.4	(–30%)	24.8	(+43%)
Personal chequable notice accounts	16.8	(+63%)	–7.8	(–13%)
Non-personal chequable notice accounts	7.8	(+773%)	7.3	(+29%)
M1+	11.0	(+13%)	32.0	(+20%)
Personal non-chequable notice accounts	–4.1	(–10%)	–28.0	(–42%)
Non-personal non-chequable notice accounts	–0.3	(–12%)	–1.4	(–29%)
M1++	9.0	(+6.3%)	–10.0	(–4%)

Note: Estimates for the aggregates differ substantially from the sum of the shifts in the components because the shifts for the aggregates are estimated independently from the shifts for the individual components.

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3. Relying on econometric techniques is especially challenging if the shifts occurred at the end of the sample period.
4. If a unitary elasticity of money with respect to output had been selected, the estimated impact of the two waves of innovation would have been 40 to 45 per cent (instead of 30 to 35 per cent) for the first wave and 35 to 40 per cent (instead of 40 to 45 per cent) for the second wave.

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Discussion

Angela Redish

The issue of what is money has plagued empirical macroeconomics for at least two centuries. Aubry and Nott examine the difficulties the problem has caused for monetary authorities in Canada in the last quarter of the twentieth century. They emerge from their examination cautiously optimistic that future research will generate a narrow monetary aggregate with a stable relationship to output and that such an aggregate can guide policy. I am less hopeful.

The paper's argument can be put into four propositions:

1. Waves of innovation in financial markets destabilized the relationship between the narrow monetary aggregates and output in Canada over the last 30 years;
2. There exists a theoretical monetary aggregate, "transactions money," that has a stable relationship with output;
3. It is possible to empirically document the measure of transactions money;
4. We should try to empirically document transactions money.

Setting out the propositions of the paper so baldly may be stretching what the authors want to argue, but it does allow one to see where the evidence needs support. I will comment on each proposition in turn.

Proposition 1

The first and far larger part of their paper documents the first proposition. Aubry and Nott examine the extent and causes of "shifts" in money demand and how such shifts have affected the correlations between money and prices and output.

They have done an excellent job of documenting the institutional changes that underlie the waves of innovation. The nature of the problem as they see it can be shown by a simple example:

	Motive for holding monetary asset		
Component	**Time 1**	**Time 2**	**Time 3**
Personal chequing account	Transactions	Transactions	Savings
Personal notice chequable account	Savings	Transactions	Transactions

where times 1, 2, and 3 loosely correspond with the seventies, eighties, and nineties; personal chequing accounts are part of M1; and personal notice chequable accounts are part of M2.

In the authors' view the appropriate aggregate is transactions money, and if an empirical counterpart of that aggregate could be found, then it would have a stable relationship with output. But no one-to-one relationship existed between a specific component of the monetary aggregates and the motivation for demanding it. In the 1970s, M1 corresponded with transactions money, but in the 1980s, Canadians began to use personal notice chequable accounts for transactions, reducing their holdings of M1. As a result the M1/GNP ratio fell.[1] In the 1990s, cash ("free credit balances") held at banks' investment dealer subsidiaries became quantitatively significant. These free credit balances are treated as equivalent to personal chequing accounts, but are used primarily for savings rather than for transactions. As a result of this trend the M1/GNP ratio rose. The authors identify other changes with similar destabilizing effects on the relationship between monetary aggregates and output.[2]

The authors estimate the amount of these shifts and their effect on the correlations of output and prices with money growth. Their methodology is not complex, but they are not trying to get precise estimates; they are just trying to make the case that important shifts occurred in 1978–86 and 1993–99. They convince me—but I didn't need much convincing—that the shifts were quantitatively significant and confounded the correlations between M1 growth and inflation.

It is the other three propositions that I think need strengthening.

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1. I am abstracting from interest rate effects to clarify the argument only.

2. In addition, they argue that the banks became less careful about classifying accounts after there were no differential reserve requirements to motivate the classification.

Proposition 2

Is there a transactions money that is stably related to output and inflation? Aubry and Nott loosely assert that all monetary theory—for example, cash-in-advance constraint models and search models—says "yes," but those models say "yes" as long as institutions are constant, and their paper is arguing for the importance of institutional change. I don't think we can conclude that an aggregate exists whose transactions velocity will be immutable in the face of changing transactions technology.

Proposition 3

If the ideal does exist, how will it be empirically implemented? This perhaps goes beyond the objectives of the paper, but the authors tantalize the reader with some implicit suggestions, and I would be interested to see at least the grounds for their optimism. For example, they may have in mind that it is possible to estimate the speculative (in the Keynesian sense) part of money demand and then determine the transactions volume residually. Is that what they mean? Is the speculative demand less unstable than the transactions demand?

In a very preliminary attempt to construct a transactions money aggregate, they define (section 2.1, "Data and methodology") four transactions aggregates that "may better represent transactions money" (see Aubry and Nott's Table 1). They compare the correlation between inflation and the growth rates of the existing monetary aggregates and that between inflation and the alternative aggregates. However, the alternative aggregates are not more highly correlated with inflation than are the traditional aggregates.

Proposition 4

How important is it that we identify transactions money? The authors argue that the ideal aggregate will (i) help the Bank know where the economy stands, (ii) improve forecasting of inflation, (iii) help build better macro models, and (iv) help financial institutions determine their market share. All these are probably fair enough (although I admit that I don't know what the last point refers to), but the authors could, I think, have strengthened their argument for a new aggregate by being more precise about its potential benefits.

Interestingly, I read (i) as saying that the ideal aggregate would not be used to implement monetary policy (i.e., as an instrument) but only to improve policy, essentially by giving a better view of the target. This

Table 1
Composition of monetary aggregates

	M1	M1+	M1++	M2++	TA1	TA2	TA3	TA4	PS
Personal accounts									
Personal chequing account	x	x	x	x			x	x	
Free credit balances	x	x	x	x					x
Personal notice—chequable		x	x	x				x	
Personal notice—non-chequable			x	x					x
Personal fixed-term, Canada Savings Bonds, mutual funds				x					x
Business accounts									
Currency	x	x	x	x	x	x	x	x	
Current accounts	x	x	x	x	x	x	x	x	
Non-personal notice—chequable		x	x	x		x	x	x	
Non-personal notice—non-chequable			x	x					

Note: TA, transactions aggregates; PS, personal savings.

reminded me of the insights of Poole (1970). He argued, using a simple stochastic IS-LM model, that interest rates and money stock can be equivalent as instruments of monetary policy in a deterministic model. In a stochastic model, however, the appropriate policy instrument depends on the relative size of shocks to the two curves. If the LM curve moves around much more than the IS (for example, because of the instability of the money-demand function), then an interest rate instrument should be used and the money stock should be permitted to adjust to demand. While there are potential problems of indeterminacy with interest rate rules, this is, I believe, close to what the Bank has been doing for the last few years—with a fair measure of success.

So the bottom line is that although Aubry and Nott have convinced me that there is no stable narrow monetary aggregate, I am less convinced than they are that there exists a theoretical concept—with an empirical counterpart—that satisfies their objectives.

Reference

Poole, W. 1970. "Optimal Choice of Monetary Policy Instruments in a Simple Stochastic Macro Model." *Quarterly Journal of Economics* 84 (2): 197–216.

Discussion

William Robson

Introduction

Their paper, Jean-Pierre Aubry and Loretta Nott state at the outset, is motivated by a view that money is important in the transmission of central bank policy to the economy and that its behaviour ought, therefore, to be the subject of central bank scrutiny. However, the problem the Bank of Canada faces now is that financial innovations are making M1, the commonest measure of transactions money, an unreliable guide for policy.

Just as innovations in the early 1980s allowed easier transfer of unneeded transactions balances into interest-earning accounts, making the stock of M1 lower than it otherwise would have been, innovations in the 1990s—the inclusion of investment dealer accounts in bank deposits, the spread of interest-bearing current accounts, and the end of differential reserve requirements for demand and notice deposits—are making the stock of M1 higher than it otherwise would be. The authors examine institutional factors affecting M1 demand and, in light of their effects, identify alternative measures that would be less sensitive to them. They test these alternative measures by checking whether their growth rates correlate with output and inflation as well as or better than the originals.

They conclude that the shifts affecting M1 demand in the early 1980s and in the 1990s have been large, reducing M1 demand by some 30 per cent in the former case and increasing it up to 45 per cent in the latter. Disappointingly, however, the search for alternative measures of money is not very successful; immunity to shifts is gained at the cost of some of the leading-indicator properties that make M1 so intriguing.

Active versus Passive Money

As a long-standing believer in M1's importance, I am pleased to see this type of investigation going on at the Bank of Canada. Discussion of monetary policy by Bank staff has long emphasized the unique status of interest rates and the exchange rate in transmitting central bank impulses to the economy (see, for example, Freedman 1995). In many such accounts, disequilibria between money stock and money demand prompt conversion to other types of deposits or extinguishment of bank debt, and the tendency of some types of money to lead output and inflation is an incidental product of the pressures exerted by factors such as interest rates, the exchange rate, and bank credit. In such models, monetary aggregates are what commercial forecasters sometimes call "show" variables—displayed to satisfy idiosyncratic clients rather than because of intrinsic importance. The lines of influence between people and money run only one way: People influence money.

Without denying the importance of transmission of central bank impulses to output and inflation through interest rates, the exchange rate, or credit, active-money models claim that money created by one agent's interaction with a bank and then passed to other agents in the purchase of a good or service affects those agents' purchasing and pricing behaviour, and so on. In this view the lines of influence between people and money run both ways. I find this latter type of model convincing for several reasons.

On a macro level, models in which the money stock passively adjusts to what the economy demands leave the general level of prices disconcertingly indeterminate. This is an apt moment for me to suggest that Aubry and Nott's approach would have been more consistent with the active-money view if they had used a more comprehensive measure than the CPI to measure inflation and deflate the monetary aggregates. In a world of passive money where inertia and the output gap determine prices, the CPI might be reasonable. However, in a monetarist world the appropriate measure is the one covering the most transactions—the GDP deflator or a variation on it that excludes imputed items.

More concretely, accounts of retailers whose falling cash receipts lead them first to cut orders to suppliers (who, in turn, trim their purchases of inventories and labour) and then, if falling receipts persist, to cut prices or cancel planned increases (and tell their suppliers to do the same) identify key features of the world that passive-money accounts leave out. Rapid creation and destruction of money to keep individual and collective holdings in line with demand would be conceivable if all agents had complete information about the relevant variables and if changes in receipts of transactions money left each agent's expectations unchanged. In real life, however, flows of money present compelling information, and the idea that changes in flows affect expenditures, output, and prices looks reasonable. Money doesn't just talk: It pushes.

The Missing Supply Side

This observation leads me to a second, more difficult reservation. Most work on monetary aggregates, including Aubry and Nott's, invokes demand-side variables alone in trying to explain behaviour that cannot be attributed to institutional or measurement changes. However, if the active-money view is right, such attempts leave something important out.

What might that be? A clue may be found in one of the most compelling criticisms of attempts to manage monetary conditions with reference to the level of short-term interest rates—namely that observable interest rates are only one side of the story and that what matters is how they compare to household and business expectations.[1] If the cost of funds is high relative to expected income growth, money is likely to come into existence more slowly and persist for less time; if the cost of funds is low relative to expected income growth, money will be created more rapidly and will persist longer. In previous work, David Laidler and I found that the spread between average private sector forecasts of nominal GDP growth and the rate on 1-month bankers' acceptances (BAs) entered a standard M1 equation significantly (Laidler and Robson 1995). Although the cyclical behaviour of this spread is similar to that of several summary measures of the slope of the yield curve, there are some differences (Figure 1).[2]

If this is a useful indicator of the impetus for money creation, then forces affecting M1 have varied over the past 30 years more than demand-side variables alone would indicate. Two events stand out: First, in the early 1980s a pronounced change in the gap between nominal growth and short-term rates from a positive to a strongly negative value occurred during a period when M1 grew more slowly than money-demand equations predicted; second, more recently a pronounced move from negative to more neutral values occurred during a period when M1 grew more quickly than money-demand equations predicted. In Laidler and Robson (1995), adding the forecast-GDP/BA-rate variable eliminated the dummy variable for the shift in M1 demand that is a major focus of Aubry and Nott's paper.

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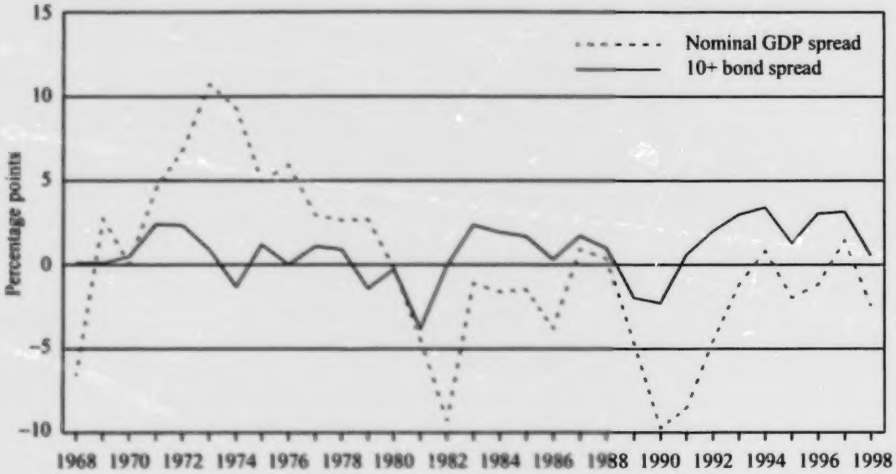
[1] Similar criticisms apply to management that makes reference to the exchange rate.

[2] In constructing Figure 1, I substitute actual nominal growth in the year shown for expected growth in the following year on the (convenient) assumption that forecasters and other Canadians tend to expect the near future to be much like the recent past.

Figure 1
GDP growth minus 1-month BA yields compared with bond spreads of 10 years or more minus 1-month BA yields



The possibility of perturbations from the supply side raises a further concern about the literature on demand shifts generally and the use of dummy variables in money-stock equations particularly. Much of what happened in the early 1980s—the movement of funds into daily-interest savings accounts and daily-interest chequing accounts that Aubry and Nott document—does not appear qualitatively different from any other response to a higher opportunity cost of holding non-interest-bearing money. Lowering the coefficient on opportunity cost by adding a dummy to an equation risks making it underpredict the response when the opportunity cost changes again—as now, when the trend toward compensating holders of transactions-oriented deposits is reducing the opportunity cost of holding them more than declines in rates on alternative assets would suggest. On this point it might pay to extend this research by using flow data to produce own-rate-of-return series for transactions balances, in case the interest rates Aubry and Nott use in calculating the 1990s shift overstate the opportunity cost in recent years.[3]

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[3] See Boessenkool, Laidler, and Robson (1997) for an exercise involving such a constructed series. I am informed that the Office of the Superintendant of Financial Institutions still collects data that could be used in this manner, and it may make sense for the Bank of Canada to review the surveys that produce these data to see if information more directly relevant to money demand could be obtained.

Some Further Comments on Empirical Relationships

Let me turn now to the second major investigation in the paper: the correlations between growth of various measures of money on the one hand and output and inflation on the other.

When it comes to correlations with inflation, the statement that currency almost always represents transactions money caught my eye. Currency is pretty heterogeneous stuff. Over the past 30 years the value of $100 and $1,000 notes in the total value of all bank notes outstanding has grown from less than 20 per cent to more than 50 per cent (the share of $1,000 notes alone has grown from 1 per cent to more than 10 per cent). One would expect a rising price level to generate higher demand for large-denomination notes, but the most rapid increase in their share occurred in the early 1990s. Since I imagine that few of us in this room keep half our cash in large-denomination notes, I wonder if their role in the economy is different from that of their small-denomination counterparts.

The only evidence I bring to this discussion (Table 1a) is from an exercise similar to that underlying Aubry and Nott's Table 2, which looks at the correlations between different money growth rates and inflation. With the exception of the series for large- and small-denomination bank notes,[4] I report results only for the money measures I was able to construct from the data on CANSIM; also, I use the deflator for "money" GDP—GDP less imputed rent (the most important expenditure item that does not involve money)—so as to focus on a price index more consistent with the quantity theory of money.

The figures for large and small notes in Table 1a cover those both inside and outside banks, so they are not strictly comparable to the other measures in the table. They hint, however, that there may be different information in the two series and that large notes are the more powerful leading indicator of inflation—suggesting that further investigation of how different denominations of notes are used might yield some insights into the behaviour of currency as a whole.

The other results from Table 1a are similar to those presented by Aubry and Nott (although the contemporaneous and year-ahead correlations between currency and M1 growth on the one hand and the money-GDP deflator on the other are 14 to 18 percentage points higher than those between money growth and the CPI). However, I read them slightly differently. The broader aggregates are informative about where inflation is now, but as for where it is likely to go next, the changes in the correlation

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[4] I am grateful to Suzanne Perreault and Matthew Leman at the Bank of Canada for their assistance in obtaining these series.

Table 1a
Correlation coefficients: Money growth versus inflation, 1969 to 1998, annual frequency

	Inflation rate (money-GDP deflator)						Difference in coefficients*		
Money growth (t)	$t-2$	$t-1$	t	$t+1$	$t+2$	$t+3$	$t+1-t$	$t+2-t$	$t+3-t$
Currency	0.31	0.42	0.55	0.70	0.69	0.59	0.15	0.14	0.04
Large notes	0.36	0.36	0.48	0.69	0.67	0.49	0.21	0.19	0.01
Small notes	0.46	0.57	0.66	0.75	0.77	0.69	0.09	0.11	0.03
Demand deposits	–0.40	–0.27	–0.21	0.01	0.21	0.24	0.22	0.42	0.45
Net M1	–0.25	–0.13	–0.04	0.25	0.45	0.42	0.28	0.48	0.46
Gross M1	–0.30	–0.14	0.01	0.30	0.48	0.42	0.29	0.47	0.41
M1++	0.50	0.69	0.64	0.68	0.65	0.53	0.04	0.01	–0.11
M2+	0.52	0.69	0.85	0.84	0.75	0.58	–0.01	–0.10	–0.27

* Difference in coefficients: [coefficient at] $t+1/t+2/t+3$ minus [coefficient at] t.

coefficients from time t to times $t+1$ and $t+2$ suggest M1 (and TA1 in Aubry and Nott's results) are more useful. (Strictly speaking, the difference in the coefficients' absolute values conveys new information, but turning points seem interesting enough to warrant attention to the total difference.)

By way of emphasis, Table 1b shows a more dynamic and, I think, more intuitive representation of the same relationship: the correlation between real money growth and changes in inflation (again, using the deflator for money GDP in both series). The ability of all forms of money to predict changes in inflation one year ahead shows starkly in this table; items in which currency looms large outperform broader measures.

When it comes to output, I have only minor additions to Aubry and Nott's observations. The correlations between quarterly growth in money deflated using the money-GDP deflator and quarterly growth in money GDP differ somewhat from those they report. The contemporaneous correlations are lower and the leading-indicator properties of M1 and TA1 (as measured by the difference between correlations at time t and times $t+1$, 2, or 3) are stronger. Tables 2a and 2b show correlations between year-over-year growth rates in money (deflated by the money-GDP deflator) and money GDP; year-over-year growth is used to reduce the importance of the fact that the large- and small-note series are not seasonally adjusted.

For the currency component it is interesting to see that the leading-indicator properties that the inflation data suggest exist in the series for large-denomination notes appear in the correlations for the entire period from 1976 to mid-1999. However, they are less apparent in the 1990s, perhaps indicating that large notes are less "active," at least in the above-ground economy, than they were previously. Turning to bank deposits, it is clear that, especially during the 1990s, the narrower aggregates more subject

Table 1b
Correlation coefficients: Real money growth versus changes in inflation, 1969 to 1998, annual frequency

	Change in inflation rate (money-GDP deflator)						**Difference in coefficients***		
Real money growth (*t*)	***t*–2**	***t*–1**	***t***	***t*+1**	***t*+2**	***t*+3**	***t*+1 – *t***	***t*+2 – *t***	***t*+3 – *t***
Real currency	–0.32	–0.35	–0.16	0.54	0.46	0.32	0.70	0.62	0.48
Real large notes	–0.43	–0.44	–0.09	0.64	0.39	0.13	0.73	0.48	0.22
Real small notes	–0.23	–0.29	–0.16	0.50	0.55	0.36	0.66	0.72	0.53
Real demand deposits	–0.15	–0.07	–0.09	0.32	0.24	0.04	0.41	0.34	0.13
Real net M1	–0.25	–0.18	–0.11	0.45	0.37	0.11	0.56	0.48	0.22
Real gross M1	–0.23	–0.13	–0.03	0.48	0.33	0.06	0.51	0.36	0.09
Real M1++	–0.10	–0.01	–0.36	0.37	0.28	0.14	0.74	0.64	0.51
Real M2+	–0.17	–0.04	0.14	0.41	0.38	0.15	0.27	0.24	0.01

* Difference in coefficients: [coefficient at] *t*+1/*t*+2/*t*+3 minus [coefficient at] *t*.

to shifts—demand deposits and net M1 above all—have been strong leading indicators of output. Frustratingly, broader aggregates intended to internalize shifts tend not to have that attractive quality; M2+ stands out for the inverse correlation between its real growth rate and that of aggregate spending.

Where Do We Go from Here?

Let me close with two observations on future directions for research. First, if money plays an active role in the transmission mechanism, the Bank of Canada ought to continue searching for aggregates that it can monitor to ensure that its actions are having their intended effect before any problems show up in output and inflation. I have noted my reservations about dummy variables and the possibility that defining opportunity cost in terms of money market rates alone understates recent declines in the cost of holding transactions money. That said, Aubry and Nott's paper sheds welcome light on potentially reliable measures of money.

Second, however, if money plays an active role in the economy, we need ways of describing its behaviour with reference to more than just variables affecting demand for it. Aubry and Nott's approach is oriented entirely around demand, asking what balances agents hold for transactions purposes. But if portfolio reallocation in preparation for spending drove

Table 2a
Correlation coefficients: Real money growth versus output growth, 1976Q1 to 1999Q2, quarterly frequency, year-over-year changes

Money/credit	**Growth of money GDP**							**Difference in coefficients***			
growth (*t*)	***t*–2**	***t*–1**	***t***	***t*+1**	***t*+2**	***t*+3**	***t*+4**	***t*+1 – *t***	***t*+2 – *t***	***t*+3 – *t***	***t*+4 – *t***
Currency	0.09	0.24	0.35	0.41	0.43	0.41	0.38	0.06	0.08	0.06	0.02
Large notes	–0.01	0.19	0.37	0.49	0.55	0.54	0.50	0.12	0.18	0.17	0.13
Small notes	0.20	0.30	0.37	0.40	0.41	0.39	0.37	0.02	0.03	0.02	–0.01
Demand deposits	–0.06	0.09	0.26	0.42	0.52	0.50	0.41	0.16	0.26	0.23	0.14
Current accounts	0.01	0.17	0.33	0.45	0.50	0.46	0.37	0.12	0.17	0.13	0.04
Net M1	–0.06	0.11	0.30	0.46	0.56	0.55	0.46	0.16	0.27	0.25	0.17
Gross M1	–0.02	0.15	0.32	0.45	0.51	0.47	0.39	0.13	0.19	0.15	0.07
M1+	0.06	0.15	0.28	0.39	0.44	0.41	0.34	0.11	0.17	0.13	0.06
M1++	0.04	0.09	0.20	0.29	0.34	0.29	0.20	0.10	0.14	0.10	0.00
M2+	0.25	0.19	0.12	0.04	–0.04	–0.11	–0.17	–0.08	–0.16	–0.23	–0.29
TA1	0.02	0.20	0.36	0.47	0.52	0.48	0.39	0.11	0.17	0.12	0.04
TA2	–0.03	0.12	0.29	0.44	0.53	0.51	0.43	0.15	0.23	0.21	0.13
Consumer credit	0.66	0.67	0.61	0.46	0.28	0.10	–0.04	–0.15	–0.33	–0.51	–0.65
Business credit	0.48	0.32	0.11	–0.13	–0.34	–0.47	–0.52	–0.24	–0.46	–0.58	–0.64

* Difference in coefficients: [coefficient at] *t*+1/*t*+2/*t*+3 minus [coefficient at] *t*.

Table 2b
Correlation coefficients: Real money growth versus output growth, 1990Q1 to 1999Q2, quarterly frequency, year-over-year changes

Money/credit	**Growth of money GDP**							**Difference in coefficients***			
growth (*t*)	***t*–2**	***t*–1**	***t***	***t*+1**	***t*+2**	***t*+3**	***t*+4**	***t*+1 – *t***	***t*+2 – *t***	***t*+3 – *t***	***t*+4 – *t***
Currency	0.15	0.35	0.50	0.58	0.55	0.48	0.37	0.07	0.05	–0.03	–0.13
Large notes	–0.13	0.08	0.26	0.38	0.41	0.38	0.31	0.12	0.15	0.12	0.05
Small notes	–0.03	0.12	0.29	0.44	0.53	0.51	0.43	0.15	0.23	0.21	0.13
Demand deposits	0.34	0.47	0.62	0.81	0.91	0.89	0.79	0.19	0.29	0.27	0.17
Current accounts	0.50	0.64	0.75	0.86	0.88	0.83	0.72	0.10	0.13	0.08	–0.03
Net M1	0.33	0.47	0.63	0.82	0.92	0.89	0.78	0.19	0.29	0.26	0.16
Gross M1	0.43	0.57	0.73	0.86	0.90	0.85	0.72	0.13	0.17	0.12	–0.00
M1+	0.13	0.29	0.47	0.63	0.67	0.59	0.44	0.15	0.20	0.12	–0.04
M1++	–0.02	0.03	0.09	0.12	0.08	–0.03	–0.18	0.03	–0.01	–0.12	–0.27
M2+	–0.77	–0.78	–0.76	–0.78	–0.79	–0.79	–0.75	–0.02	–0.03	–0.03	0.01
TA1	0.48	0.64	0.78	0.88	0.90	0.83	0.72	0.10	0.12	0.05	–0.06
TA2	0.40	0.57	0.73	0.85	0.87	0.79	0.65	0.12	0.14	0.06	–0.08
Consumer credit	0.57	0.48	0.37	0.19	0.03	–0.07	–0.13	–0.18	–0.34	–0.44	–0.50
Business credit	0.39	0.23	0.06	–0.09	–0.21	–0.23	–0.24	–0.16	–0.27	–0.30	–0.31

* Difference in coefficients: [coefficient at] *t*+1/*t*+2/*t*+3 minus [coefficient at] *t*.

money growth, one might expect to see correlations between credit and output growth similar to those between money and output growth. Tables 2a and 2b show that not to be the case.[5]

What may be more helpful is to ask not where active money originates, but where it ends up—in what basket, to mix metaphors, do these hot potatoes land? From that perspective, we would include business current accounts not so much because they hold money about to be spent, but because they hold money that has just been spent. Similarly, we would exclude free credit balances at investment dealers not because their holders do not use them for buying goods and services, but because their holders did not receive them from selling goods and services. In short, if we want to find "active" money in the economy, we need to look not for situations in which people are influencing money, but for situations in which money is influencing people.

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[5] Intriguingly, in the 1990s, consumer credit *acceleration* is more closely correlated than consumer credit growth with growth in transactions balances.

General Discussion*

Aubry agreed with Robson that it would be worth trying to put more emphasis on the active-money view, but he noted that even when focusing on the supply side, it is still important to distinguish between money shocks that occur when the structure of financial institutions is stable versus shocks that occur in an environment of institutional changes. Robson noted that he prefers to use the GDP deflator minus imputed rent. Aubry also liked the idea of focusing on price measures other than total CPI, either broader measures like the GDP of final domestic demand deflators or narrower ones like core CPI. He used the CPI largely because it is the series that the Bank targets.

Tom Rymes pointed out that because shifts in banks' liabilities must be matched by similar shifts in banks' assets, one should try to measure the price of banking services. To this end, one should look not only at interest rate levels and spreads, but also examine how service charges on all kinds of deposits are changing over time. He could not see how one can understand the monetary transmission mechanism without a good model of the banking sector's output. Aubry liked this suggestion and added that we do not currently have good measures of incentives associated with different types of instruments and that this makes empirical work difficult.

Stefan Gerlach asked if one could not use purely statistical criteria to determine a measure of transactions money, as is done with determining underlying inflation. For example, one could disaggregate a narrow aggregate like M1 into its various sub-components and pick the components that have the strongest correlation with the macro variables of interest. Also, he pointed out that in order to get a good measure of transactions money, one also needs a good measure of transactions themselves. He wondered if real GDP is the right measure given the changes that take place over time in financial market activity and other sectoral shifts. Aubry replied that it might not be appropriate to use only statistical criteria to determine transactions money. Because this approach, which has often been used in the past, has not provided very satisfactory results, he argued, we should use statistical criteria in combination with theory and knowledge of the institutions.

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* Prepared by Agathe Côté.

Marc Pinsonneault asked if any evidence exists of a link between deposits at investment dealers and either output or inflation. Aubry replied that it is difficult to verify the existence of such a link given that the data on dealer accounts have only been available for a short period and that this period is characterized by a sharp increase in the popularity of these accounts. The jury is still out as to whether dealer accounts behave more like transactions accounts or like savings accounts. Even if dealer accounts are more like savings accounts, they may still have some predictive power for output and inflation, since other studies presented at this conference (e.g., Kim McPhail's) will show that broad monetary aggregates also help predict output and inflation. Serge Coulombe wondered if there might not be an aggregation problem with the current definitions of monetary aggregates (i.e., if components do not all have the same transactions velocity and their share varies over time, then we may end up with an aggregate that is not meaningful). Aubry replied that variable-weight aggregates (e.g., divisia) may help deal with institutional changes as well as with the aggregation bias.

William Whitesell wondered if Robson's finding of a higher correlation between inflation and money, compared with what Aubry and Nott found, might be due not only to his use of an alternative measure of prices, but also to the use of annual rather than quarterly data. Whitesell's own research suggests that the correlations are stronger with lower-frequency data. He also inquired how the long lags between money, output, and inflation could be consistent with a cash-in-advance model. These lags might instead reflect a wealth effect. Robson clarified that he used annual data for inflation but quarterly data for output, the same as Aubry and Nott did. He also argued that the long lags cause a problem for both the active- and the passive-money views and that they could reflect some form of non-linearity. For example, it may well take more than one month of unexpected cash receipts before retailers decide to change their behaviour. Aggregating such information over millions of individuals can possibly produce the sort of lags that are found in macroeconomic studies.

Broad Money: A Guide for Monetary Policy

Kim McPhail

Introduction

There is widespread agreement that in the long run, inflation is a monetary phenomenon. But the nature of the links from money to inflation is less clear-cut. And the notion of which monetary aggregate is more relevant for inflation and for use in monetary policy-making is also unclear.

From a policy perspective, two ideas help establish that money is an important policy variable contributing to inflation. The first is that there is a stable long-run money demand. This quantifies the long-run relationship between money and prices, taking into account the other variables influencing the long-run money-demand relationship without drawing the line of causality between them. The second idea is that money helps to forecast inflation one or two years out, even after some other variables have been taken into account. The view that money predicts inflation is consistent with the quantity theory, which associates inflation with past money growth, and with buffer-stock models, which hold that money in excess of its long-run demand tends to increase spending and puts upward pressure on prices. That money predicts inflation is also consistent with the idea that money growth is influenced by inflation expectations, which explains why money growth leads inflation. If better forecasts of inflation can be obtained by including money, then a policy strategy that includes money has a higher chance of meeting the inflation targets and keeping inflation within the target bands.[1]

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* I would like to thank Jean-Pierre Aubry, Kevin Clinton, Agathe Côté, Jim Dingle, Walter Engert, David Laidler, and Jack Selody for helpful comments.

Money's usefulness as a monetary policy tool is viewed differently in different countries. In the euro area the European Central Bank has selected for a broad measure of the money supply a reference rate that will be used in conducting monetary policy. In the United States many argue that, because of velocity shifts and financial innovations, money is a less useful policy indicator than it used to be.[2]

This paper explores the relationship between broad money and inflation in Canada.[3] First, I investigate whether stable long-run demand functions exist for broad money, and second, I ask whether broad money helps to forecast inflation even when other variables such as output and interest rates are taken into account. My results suggest that stable long-run demand functions for broad money do exist and that broad money is useful for forecasting inflation at 4- and 8-quarter horizons—the horizons of most interest to monetary policy.

Many measures of broad money are possible. These can be viewed as lying along a continuum where at one end broad money provides a high degree of liquidity and at the other end, components with less liquidity are present. Theory makes it difficult to select a cutoff point to determine the optimal degree of liquidity of broad-money assets. However, theory suggests that narrower measures of broad money, with more-liquid components, might more easily account for the leading-indicator properties of broad money. Consequently I estimate demand functions and indicator models for a variety of broad-money definitions. The estimation results suggest that some of the narrower, more liquid of the broad-money measures are the most useful. Measures of money broader than M2 and M2P, particularly those with mutual funds and Canada Savings Bonds (CSBs), do particularly well.

1 Long-Run Money-Demand Functions

The components of broad money play many roles in the economy. Some serve as means of exchange because they include transactions balances for the purchase of goods and services associated with the narrower transactions-based aggregates. Broad money also includes some other types of deposits or financial instruments that, while not purely transactions-oriented, can easily, quickly, and for little or no cost (in time and money) be converted to transactions balances.[4] Broad money also serves the precautionary money-demand motive because it can inexpensively buffer income and spending shocks. It also serves as a store of value, being an important component of how wealth is allocated. This function may be gaining importance because demographic forces favour high savers for whom wealth management is an increasing concern.

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[1] At the Bank of Canada, money is used informally as an indicator but is not included in the Bank's Quarterly Projection Model (QPM).

[2] In Humphrey-Hawkins testimony in July 1993, Chairman Alan Greenspan said that the Federal Reserve would no longer use monetary targets as guides for monetary policy (Bernanke et al. 1999, 325).

[3] Aubry and Nott in this conference volume deal with narrow money in Canada.

No guideline exists as to which motive dominates the demand for broad money. Motives may differ, depending on which of many possible measures of broad money is chosen. The means of exchange and precautionary demands would presumably be more important to the narrower definitions of broad money because sources of immediate liquidity are important to these motives for holding money. Clearly the store-of-value function would dominate the broadest measures of broad money, the ability to convert money to cash at short notice being less important to that function. The transactions motive and precautionary money demand give rise to most "structural" explanations as to why money helps to forecast inflation. Consequently, one might expect the narrower definitions of broad money to be most useful empirically.

Broad money is held in both the personal and non-personal sectors. The motives for holding money are most clearly articulated for the personal sector, but the data on various measures of broad money used here make it difficult to make a personal/non-personal distinction. For the most part the models here apply the concept of long-run money demand to the data that are readily available, such data usually being total rather than personal holdings of broad money.

A long-run money-demand specification that encompasses the various motives for holding money is

$$m^d = a_0 + p + a_2 y + a_3 w + a_4 i^o - a_5 i^c . \tag{1}$$

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[4] Traditional measures of broad money include term deposits. Some term deposits are pre-encashable (i.e., they may be cashed before their maturity date) and are therefore very liquid, while others are non-pre-encashable and therefore less liquid. Even among non-pre-encashable deposits, some are of very short maturity (e.g., 90 days) and therefore much more liquid than, say, 5-year non-pre-encashable deposits. Others may be of longer maturity originally but the remaining term to maturity may be short. Ideally, in defining broad money that is very liquid, some component of term deposits should be omitted. But data are not available to satisfactorily break down liquid versus less-liquid term deposits.

I will estimate the model on a quarterly basis. Long-run money demand depends on income, y, proxied here by real GDP, and on wealth. Two definitions of wealth, w, are used. One, *rtw*, consists of real total wealth in the economy, and the second, *rnhw*, subtracts human wealth to arrive at a measure of real non-human capital.[5] Although the GDP deflator would be most consistent with the use of real GDP in the money-demand equation, the price variable, p, is instead taken to be the total consumer price index (CPI) because that price is of great interest to policy, the Bank of Canada's inflation targets being defined in terms of the CPI. In any case, over the forecasting horizons of most interest here, two inflation measures—the GDP deflator and the CPI—are highly correlated. The restriction of a unitary price elasticity is given by theory and makes the long-run level of real balances independent of the price level or the money supply. I take this to be one of the strongest restrictions in monetary theory and choose not to examine models that do not have long-run price homogeneity.[6] The own rate of return on broad money, i^o, is proxied by the rate of return on 5-year term deposits at banks. This is a very narrow and imperfect proxy for the own rate of return on broad money, but unfortunately very few rates of return on other components of broad money are available over the entire sample period.[7] The competing rate, i^c, is a weighted average of the non-monetary assets in non-human wealth, constructed for a representative definition of broad money.[8]

2 Definitions of Broad Money

One way of choosing among broad-money measures is to organize the various definitions according to liquidity. Liquidity has been defined many ways, but one of the simplest and most useful is that of *The Concise Oxford Dictionary* (1976): "An asset is liquid if it is easily convertible to cash." "Easily convertible to cash" is a short form that can include considerations such as transaction costs, minimum transaction requirements, and risk of capital loss. All of these factors make it less "easy" to convert the asset into cash. Because many of these criteria increase or decrease liquidity, it is difficult to rank the various definitions of broad money; an aggregate may rank highly according to one criterion but low according to another. Nevertheless, Table 1 shows the various definitions used and attempts to rank them from most liquid to least liquid. All the aggregates under consideration are simple-sum measures.

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[5] Both measures of wealth are taken from Macklem (1994).

[6] When broad money is defined as M2P+CSB+mutual funds at financial institutions, a test of price homogeneity cannot be rejected. For the other preferred aggregate, M2P+CSB+all mutual funds, price homogeneity is rejected. See Table 1 for definitions of broad-money aggregates.

[7] Strictly speaking, a separate own rate should be calculated for each definition of broad money used here. That is another reason why the proxy for the own rate used here is imperfect.

[8] The rates of return on non-monetary assets in non-human wealth are given by the 2-quarter growth rates of the TSE index for equity, the growth rate of the price of multiple listings for housing, the growth rate of the CPI for consumer durables, and the rate on 3- to 5-year government bonds for other assets. The shares are given by the share of the non-monetary asset in total assets. Strictly speaking, these shares change for each definition of the broad-money aggregate because, as the aggregates get broader and broader, more assets become monetary and fewer non-monetary. However, in the empirical analysis I use a representative measure of broad money to specify the shares, and these are held constant over all possible definitions of broad money.

All of the definitions for broad money used here are from previous studies. As a result there may be some gaps between the various definitions or some definitions that do not seem obvious from a theoretical perspective. However, the limitations of this are more than outweighed by the benefits of having the data readily accessible. A methodology of creating various possible definitions of broad money from first principles is beyond the scope of this paper.

At the most liquid end of the spectrum, we begin with M2 and M2P, the conventional broad-money aggregates. Next, mutual funds at banks and other institutions are added to M2P, yielding M2PFIQ and M2PALLQ. Mutual funds have become increasingly important in household portfolios during the 1990s and are easily convertible into cash. Substitutions between M2P and mutual funds are clearly discernible in the data. Next, CSBs are added to M2PFIQ and M2PALLQ, producing M2P_Adj and M2PP_Adj respectively. CSBs in a variety of denominations are sold to individuals and are redeemable without penalty at any time.[9] In short, CSBs are easily convertible into cash. Then treasury bills and provincial savings bonds are added, creating M2PP. When combined with mutual funds at banks and total mutual funds, M2PPFIQ and M2PPALLQ are created. Provincial savings bonds are also easily convertible into cash. Treasury bills are also very liquid, with minimal risk of capital loss. In the early 1980s, households' direct holdings of treasury bills grew rapidly, spurred on by high yields and falling commissions charged by financial institutions or investment dealers for the retail purchase of treasury bills.

M3β adds short-term government bonds, mortgage-backed securities, and foreign currency deposits to M2PPALLQ. These are assets with some risk of capital loss and thus somewhat less liquid than previous

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[9] The exceptions are the new Premium Savings Bonds, which can be redeemed only at one time during the year. These are not important in terms of the overall size of the aggregates.

Table 1
Broad monetary aggregates and measures of wealth

Aggregate	Description	Level at end of 1996 ($ billions)
M2	M1+ non-personal notice deposits + personal savings deposits at banks	409
M2P	M2 + TML[a] + CUCP[b] + life insurance + personal deposits at government-owned savings institutions + money market mutual funds	637
M2PFIQ	M2P + mutual funds at financial institutions[c]	715
M2PALLQ	M2P + all mutual funds[c]	829
M2P_Adj	M2PFIQ + CSBs	717
M2PP_Adj	M2PPALLQ + CSBs	834
M2PP	M2P + provincial and Canada Savings Bonds + treasury bills[d]	789
M2PPFIQ	M2P_Adj + provincial savings bonds + treasury bills[d]	837
M2PPALLQ	M2PP_Adj + provincial savings bonds + treasury bills[d]	950
M3β	M2PP + mutual funds + 1- to 3-year government bonds[d] + mortgage-backed securities + Canadian residents' foreign currency deposits booked in Canada	1,133
LLβ	M3β + bankers' acceptances + commercial paper issued by non-financial corporations	1,184
M5	LLβ + other federal, provincial, municipal, and corporate bonds held by households	1,502
NHW	Non-human wealth	1,842
TW	Total wealth	9,558

Note: My definition of M2PP (referred to as M2d in Atta-Mensah [1995]) is not the same as the definition of M2PP used elsewhere and published by the Bank of Canada. What the Bank defines as M2PP is called M2PP_Adj in this paper. Also, what the Bank defines as Adjusted M2P is called M2P_Adj in this paper.

a. Deposits at trust and mortgage loan companies.
b. Deposits at credit unions and caisses populaires.
c. Excludes capital gains and losses.
d. Excludes those held by financial institutions.

assets. LLβ adds bankers' acceptances and commercial paper, and M5 adds other bonds held by households, although such bonds, being subject to capital variation, are convertible into cash at uncertain values.

Most of these definitions of broad money consist of holdings of the personal and non-personal sectors, though in some cases only personal sector holdings are added (see Table 1). M5 goes beyond what some would call "money," but it represents one measure of fairly liquid financial assets. The purpose of this paper is not to characterize the optimal definition of broad money from a theoretical viewpoint, but to determine from an empirical standpoint which measures of broad money appear useful. Another thing I look for in the empirical results is their consistency across different definitions of broad money, as this helps us to assess the robustness of the results.

In Figure 1, I plot the progress of these broad-money aggregates over time, and in Figures 2 to 4, I show the progress of some of the explanatory variables of the money-demand functions to be estimated. Table 1 shows the relative size of the broad aggregates at the end of 1996. By way of comparison, the narrow aggregate M1 represents about $80 billion.

Before estimating long-run money-demand functions, unit-root tests were run on all the variables used. Table 2 shows that many broad-money aggregates appear to be I(2), though the power of the augmented Dickey-Fuller (ADF) tests is known to be low, and so an I(1) outcome may be suspected. The remaining broad-money aggregates are I(1). However, real money balances, except M3β and LLβ, are I(1), implying that money growth and inflation are themselves cointegrated. The other variables used in the long-run money-demand estimation are I(1). Prices are borderline I(2).

3 Unrestricted Long-Run Money-Demand Estimates

Long-run money-demand functions are estimated using the Johansen-Juselius vector-error-correction model (VECM). Estimates are for the period 1970Q1 to 1998Q4 for the first six monetary aggregates under consideration. For the last six aggregates, data are readily available only until 1996Q4, and so my regressions end then.[10] In accordance with equation (1) the variables that make up the VECM are real balances, output, wealth, and own and competing rates. The order of the VECM is selected using Akaike's final prediction error (FPE) criterion. Estimation results, shown in Table 3, are mixed.

Real total wealth, *rtw*, was initially tried with all aggregates. However, I only found reasonable estimates by using real non-human wealth, *rnhw*, for the broadest of the broad aggregates. The fact that different measures of wealth are required to produce satisfactory money-demand functions is not very encouraging.

The estimates for income and wealth elasticities vary widely for different definitions of broad money, even when the definitions are very similar. Income elasticities range from a low of 0.01 for M5 to a high of 1.60 for M2PFIQ. Wealth elasticities vary from a range of 0.02 for M2P and M2PFIQ to a high of 1.29 for M2PALLQ, an aggregate that differs from M2PFIQ only by adding mutual funds. The sum of the income and wealth

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[10] Since it is important to have up-to-date data on monetary indicators, this is one strike against focusing on an aggregate that is limited by data being readily available only until 1996.

Figure 1a
Broad monetary aggregates, M1 to M2PP_Adj

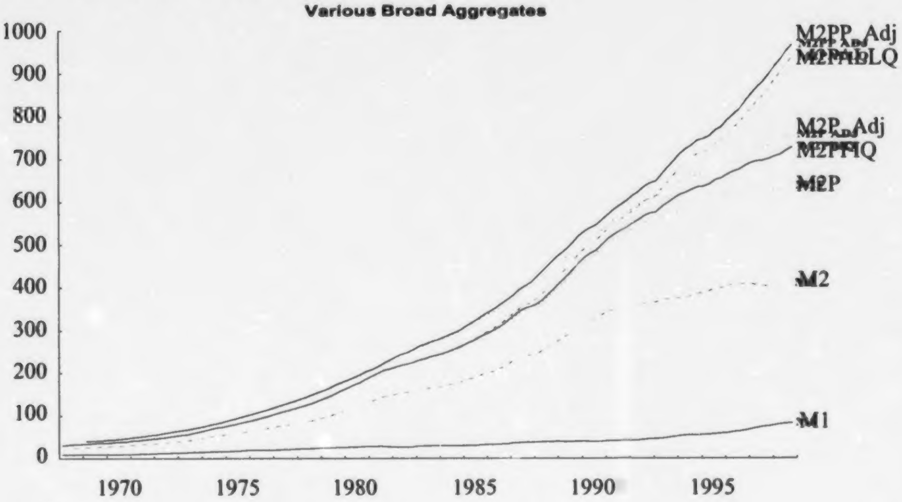
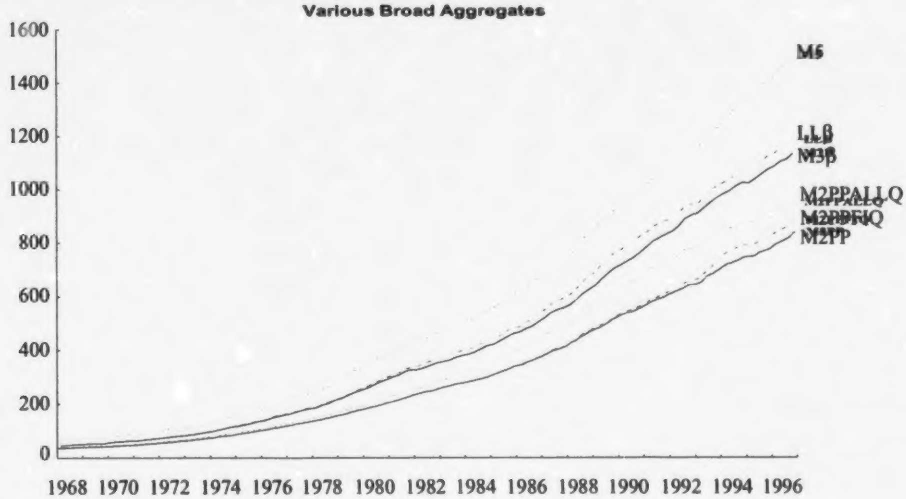


Figure 1b
Broad monetary aggregates, M2PP to M5



elasticities appears more stable, suggesting that it may be difficult to separately identify the effects of these variables. Thus these results are not very consistent across different money-supply definitions.

Own interest rate semi-elasticities are generally found to be positive, although M2PFIQ and M2PP yield counterintuitive negative interest rate semi-elasticities. Again, the semi-elasticities range quite widely over various

Figure 2
Per-capita wealth

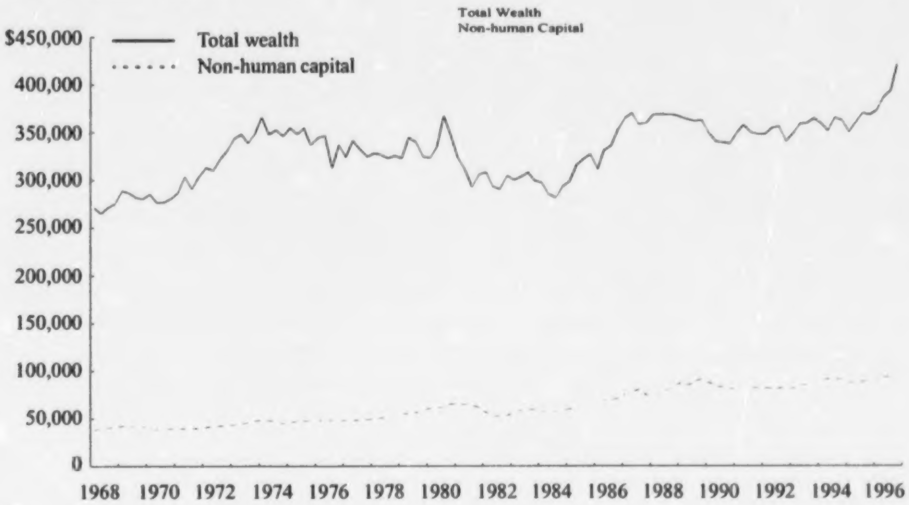
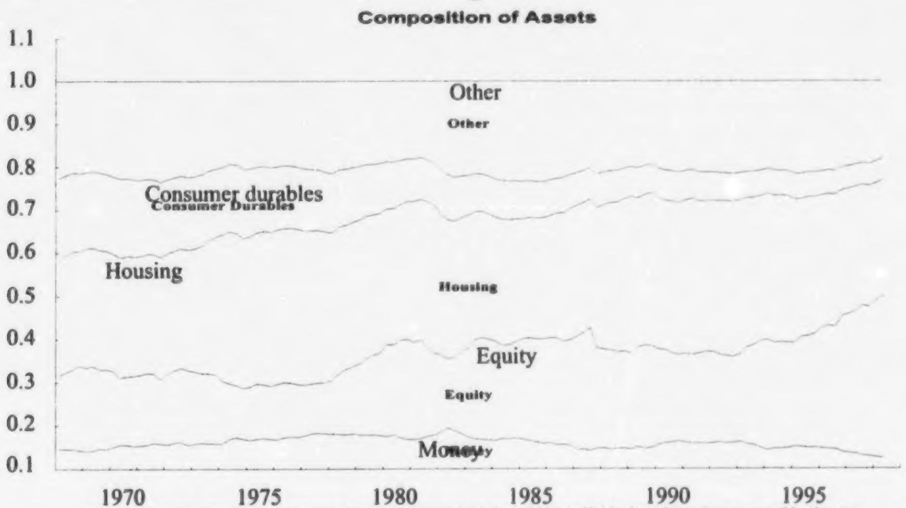
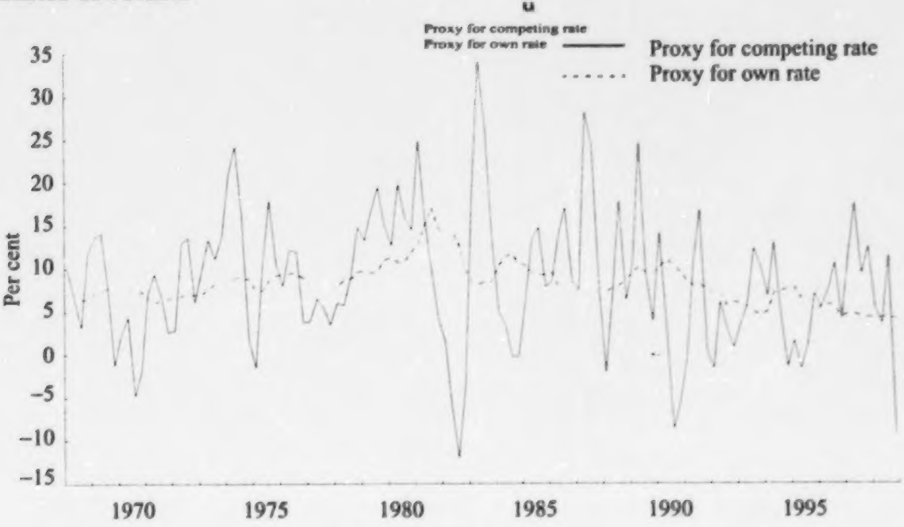


Figure 3
Composition of assets



Note: "Money" is currency and domestic and foreign currency deposits held by individuals and unincorporated businesses. "Other" includes government and corporate bonds and other financial assets.

Figure 4
Rates of return



broad-money definitions, from a low of close to 0 to a high of 0.034 for M5. Semi-elasticities for competing rates are negative, between –0.016 and –0.044.

The proxy for the own rate is very imperfect, and when it is used with broader and broader aggregates that contain components whose return varies with market rates, it becomes less useful. Also, as the aggregates become broader and broader, there is less scope to find other financial assets that can be substituted into broad money, presumably making the own rate of return a less important variable.

Generally, two cointegration vectors are found.[11] This is not surprising; in a structural model, money demand would be one cointegrating vector and the interest rate differential, found to be stationary using ADF tests, would be the other. In cases where there are two cointegrating vectors, the one shown in Table 3 is the vector most closely correlated to the stationary part of the system (i.e., that is associated with the largest eigenvalue). But because of the existence of more than one cointegrating vector, an identification problem may exist, and we should be cautious in

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[11] I use critical values from Johansen and Juselius (1989) for the λ-max and trace statistics. A cointegrating vector is considered to exist if both the trace and the λ-max statistics are significant at the 5 per cent level.

Table 2
Unit-root tests

	Augmented Dickey-Fuller tests				
	First difference	Level		First difference	Level
		Sample: 1969Q1–1998Q4			
*r*M2	−3.2*	−1.6	M2	−3.4*	0.7
*r*M2P	−4.0*	−1.0	M2P	−2.9	−0.3
*r*M2PFIQ	−4.3*	−2.5	M2PFIQ	−3.3*	−0.8
*r*M2PALLQ	−4.2*	−3.3*	M2PALLQ	−3.0	−1.1
*r*M2P_Adj	−3.3*	−1.4	M2P_Adj	−3.2*	0.2
*r*M2PP_Adj	−3.3*	−3.1	M2PP_Adj	−3.3*	0.2
		Sample: 1969Q1–1996Q4			
*r*M2PP	−3.2*	−0.3	M2PP	−2.9	0.9
*r*M2PPFIQ	−3.8*	−0.6	M2PPFIQ	−3.2*	1.6
*r*M2PPALLQ	−4.0*	−2.3	M2PPALLQ	−3.6*	1.7
*r*M3β	−2.8	−2.5	M3β	−2.1	−1.2
*r*LLβ	−3.0	−2.3	LLβ	−2.2	−0.9
*r*M5	−3.4*	−2.6	M5	−2.5	−0.6
y	−6.1*	−1.6	i^b	−6.8*	−2.5
rtw	−3.6*	−2.6	i^c	−9.0*	−3.0
$rnhw$	−4.4*	−2.7	$i^b – i^c$	−8.7*	−3.8*
p	−3.1	−0.5			

Notes: Unit-root tests are based on the regressions $\Delta x_t = b_0 + b_1 t + A(L)\Delta x_{t-1} + b_2 x_{t-1}$.
The order of $A(L)$ is chosen on the basis of Akaike's final prediction error (FPE) criterion.
All variables except interest rates are in logs. A monetary aggregate prefixed by an *r* indicates that the nominal aggregate has been deflated by the CPI. The sample for aggregates *r*M2PP through M5 ends in 1996Q4.
* Significant at the 5 per cent level.

interpreting the cointegration vector shown as long-run money demand. This lack of identification probably primarily affects the interest rate coefficients.[12]

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[12] If the two structural cointegration vectors in the data are given by the money-demand function and the interest rate differential

$$rm - a_1 y - a_2 w - a_3 i^o + a_4 i^c$$
$$i^o - i^c,$$

then there is an identification problem. But every possible cointegration vector must be a linear combination of the two structural vectors, yielding

$$(rm - a_1 y - a_2 w - (a_3 - b))i^o + (a_4 - b)i^c,$$

where b is the weight given to the second equation. b affects only the interest rate coefficients, meaning that the other coefficients are identified and estimated consistently by the Johansen-Juselius procedure.

Table 3

Estimates of long-run money demand, 1970Q1–1998Q4

Variables	Order of VECM[a]	First CI vector[b]	Corresponding loadings	Number of CI vectors[c]
*r*M2,*y*,*rtw*,i^b,i^c	3	[1 −1.26 −0.31 −0.028 0.026]	[−0.01* 0.01 −0.23 1.8* −13.4*]	2
*r*M2P,*y*,*rtw*,i^c	3	[1 −1.57 −0.02 −0.014 0.021]	[−0.02* 0.01 −2.4 2.2* −12.7*]	1
*r*M2PFIQ,*y*,*rtw*,i^b,i^c	3	[1 −1.60 −0.02 0.005 0.015]	[−0.03* 0.00 −5.2 2.7* −14.5*]	2
*r*M2PALLQ,*y*,*rtw*,i^b,i^c	4	[1 −0.85 −1.29 −0.032 0.042]	[−0.01* −0.00 3.19 1.4* −15.9*]	2
*r*M2P_Adj,*y*,*rtw*,i^b,i^c	3	[1 −1.54 0.08 −0.004 0.016]	[−0.02* 0.02* 0.79 2.7* −18.4*]	1
*r*M2PP_Adj,*y*,*rtw*,i^b,i^c	3	[1 −1.34 −0.41 0.005 0.022]	[−0.02* 0.01 4.0 1.9* −20.4*]	1
*r*M2PP,*y*,*rnhw*,i^b,i^c	2	[1 −0.60 −0.55 −0.051 0.044]	[−0.01 0.00 0.01 0.6* −15.1*]	2
*r*M2PPFIQ,*y*,*rnhw*,i^b,i^c	2	[1 −0.69 −0.60 −0.023 0.027]	[−0.01* 0.01* 0.02 1.0* −26.9*]	2
*r*M2PPALLQ,*y*,*rnhw*,i^b,i^c	2	[1 −0.73 −0.65 −0.006 0.020]	[−0.01 0.01 0.02 1.2 −38.9*]	2
*r*M3β,*y*,*rnhw*,i^b,i^c	2	[1 −0.16 −0.85 −0.028 0.041]	[−0.01* 0.00 0.01 0.7* −17.5*]	2
*r*LLβ,*y*,*rnhw*,i^b,i^c	2	[1 −0.48 −0.74 −0.019 0.026]	[−0.01* 0.01 0.02 1.0* −27.4*]	3
*r*M5,*y*,*rnhw*,i^b,i^c	2	[1 −0.01 −0.94 −0.034 0.038]	[−0.01 0.01* 0.01 0.01* −18.9*]	2

Note: Sample for *r*M2PP through *r*M5 ends in 1996Q4.

a. VECM chosen on the basis of Akaike's FPE criterion.

b. Cointegration vector.

c. According to Johansen-Juselius trace and λ -max statistics.

* Significant at the 5 per cent level.

The loadings for real balances are negative and generally significant, though small. This is consistent with the idea that real balances should decline when money is greater than its long-run demand. Money gaps, the difference between actual money and its long-run demand as estimated by the Johansen-Juselius cointegration vectors, have a positive effect on own rates and a negative effect on competing rates. This may reflect a market-clearing mechanism as well. One of the ways for positive money gaps to be eliminated is for money demand to rise through an increase in own rates or a decrease in competing rates. Loadings for output are generally small and insignificant. Those for wealth are usually insignificant.

In summary, the estimates of Table 3 provide limited support for the existence of a long-run money-demand function of the type specified in equation (1). Estimated coefficients generally have the expected signs. However, the estimated demand functions are not stable across different definitions of broad money. This is disconcerting because it is difficult to explain from an economic point of view why monetary aggregates that differ by only one or two components should have demand functions that are very different. Additional results (not reported) indicate that the estimated long-run money-demand functions are not stable when estimated over various subsamples and that the estimates of long-run demand are very sensitive to the choice of the VECM order. Thus these results are not very robust.

4 Restricted Long-Run Money-Demand Functions

Given the results in the previous section, I dropped the wealth variable, which appeared to contribute to the instability of the Table 3 estimates. The proxy for the own rate is also dropped; it had the wrong sign for several of the broad aggregates considered in Table 3. The restricted system consists of m, y, and i^c, a very typical choice of variables for money-demand functions. Estimates for this system are shown in Table 4.

The estimates of long-run money demand associated with these systems are quite uniform across different measures of broad money. This is reassuring because it is difficult to explain why adding a component to one measure of broad money could produce substantially different estimates of income elasticity and interest rate semi-elasticity.

A unique cointegration vector is found for all measures of broad money. Income elasticities range between 1.4 and 1.8, the broader measures of money tending to have the larger elasticities. Interest rate semi-elasticities range between –0.02 and –0.04.

The effect of money gaps on real balances is, with one exception, significantly negative, the real balances having larger loadings than those

Table 4
Restricted estimates of long-run money demand, 1970Q1–1998Q4

Variables	Order of VECM[a]	First CI vector	Corresponding loadings	Number of CI vectors[b]
rM2,y,i^c	4	[1 −1.39 0.022]	[−0.02* −0.03* −25.7*]	1
rM2P,y,i^c	4	[1 −1.54 0.022]	[−0.03* −0.02* −23.8*]	1
rM2PFIQ,y,i^c	4	[1 −1.64 0.020]	[−0.05* −0.02 −25.0*]	1
rM2PALLQ,y,i^c	4	[1 −1.84 0.040]	[−0.05* −0.02 −18.9*]	1
rM2P_Adj,y,i^c	4	[1 −1.47 0.015]	[−0.06* 0.03 −26.7*]	1
rM2PP_Adj,y,i^c	4	[1 −1.70 0.032]	[−0.05* 0.00 −29.7*]	1
rM2PP,y,i^c	4	[1 −1.71 0.023]	[−0.02 −0.02 −28.3*]	1
rM2PPFIQ,y,i^c	4	[1 −1.73 0.017]	[−0.05* 0.01 −29.2*]	1
rM2PPALLQ,y,i^c	4	[1 −1.82 0.020]	[−0.06* 0.02 −30.1*]	1
rM3β,y,i^c	4	[1 −1.63 0.026]	[−0.08* −0.02 −22.1*]	1
rLLβ,y,i^c	4	[1 −1.73 0.019]	[−0.11* −0.01 −29.2*]	1
rM5,y,i^c	4	[1 −1.57 0.029]	[−0.07* −0.03 −23.0*]	1

Note: Sample for rM2PP through rM5 ends in 1996Q4.
a. VECM chosen on basis of Akaike's FPE criterion.
b. According to Johansen-Juselius trace and λ-max statistics.
* Significant at the 5 per cent level.

found in the full system that was presented in Table 3. This indicates a faster elimination of money gaps via changes in real balances. The effects of money gaps on output are, again, small and generally insignificant. This is not generally supportive of a buffer-stock story, in which one would expect excess money to put upward pressure on spending. The effect of money gaps on interest rates is negative and always statistically significant. This could represent a liquidity effect, whereby excess supply of money puts downward pressure on rates of return.

The long-run money-demand estimates shown in Table 4 are similar for different definitions of broad money, and they have estimated coefficients that are consistent with economic theory.[13]

5 Stability of Long-Run Money Demand

In the United States, economists have argued that money is no longer a useful policy variable. For example, Estrella and Mishkin (1996) state that

> Since the 1980s, advocates of a central role for monetary aggregates have been confronted with a deterioration of the traditional relationships between money and policy targets. . . . (p. 1)

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[13] When mutual funds are defined to include capital gains and losses, estimates of long-run money demand are similar to those in Table 4.

> Therefore, we must conclude that the monetary aggregates, the monetary base, and M2 in particular, are currently not very useful for monetary policy purposes. Whatever their informational content may have been in earlier time periods, they do not seem to provide adequate and consistent information at present in the United States. (p. 28)

It is, therefore, interesting to examine whether long-run broad-money demand and indicator-model content appear stable in Canada or whether the same deterioration occurred in the 1980s in Canada as it did in the United States. This section examines the stability of the long-run broad-money-demand functions.

In Table 5, the sample is split into two subsamples, one from 1970Q1 to 1984Q4 and the second from 1982Q1 to 1998Q4. With the exception of M2, LLβ, M5, and possibly M2PALLQ, the long-run demand functions appear reasonably stable across the subsamples.[14]

In part this degree of stability is surprising because we know that in recent years the substitution towards mutual funds and away from deposits included in M2P has caused M2P growth to decline fairly sharply. Yet this shift does not show up as instability in the demand for M2P and M2 reported here. It may be that the shift is too recent to have a great influence on the evidence of stability, or it may be that the shift is not large enough to show up as marked differences in the long-run money-demand function. In any case this substitution is internalized within broader aggregates such as M2P_Adj and M2PP_Adj.

In Table 6, estimates are shown of long-run money demand over the entire sample, with an order of 3 for the VECM. This is to test for the model's sensitivity to changes in this parameter. A drastic change in long-run money-demand estimates could be evidence of the underlying model's instability. However, Table 6 shows that the model is essentially immune to this change.

Overall, the long-run money-demand functions appear to be stable; estimation results show little difference across various subsamples and for different orders of the VECM. The estimation results are also robust across different definitions of broad money. There is no evidence that shifts in velocity or financial innovation have undermined the stability of the long-run money-demand relationship for most measures of broad money since the 1980s. In contrast to narrower aggregates such as M1, with the broad aggregates no dummy or shift variables are required to produce a long-run

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[14] Chow-type tests detect no break in the demand functions in the entire sample for any of the aggregates except M2.

Table 5
Estimates of long-run money demand over two subsamples

	1970Q1–1984Q4		1982Q1–1998Q4[a]	
Variables	**CI vectors**	**Loadings**	**CI vectors**	**Loadings**
rM2,y,i^c	[1 −0.82 −0.045]	[0.00 0.05 25.7]	[1 −1.35 0.027]	[−0.01 −0.01 −49.6]
rM2P,y,i^c	[1 −1.78 0.024]	[−0.07 −0.06 −21.8]	[1 −1.54 0.025]	[−0.02 −0.01 −51.4]
rM2PFIQ,y,i^c	[1 −1.78 0.023]	[−0.08 −0.06 −21.7]	[1 −1.77 0.025]	[−0.01 −0.00 −51.4]
rM2PALLQ,y,i^c	[1 −1.78 0.022]	[−0.08 −0.06 −21.5]	[1 −2.14 0.038]	[−0.03 −0.00 −47.8]
rM2P_Adj,y,i^c	[1 −1.53 0.010]	[−0.10 0.04 −2.7]	[1 −1.57 0.021]	[−0.05 −0.00 −38.8]
rM2PP_Adj,y,i^c	[1 −1.80 0.022]	[−0.10 0.04 −3.7]	[1 −1.70 0.048]	[−0.01 −0.00 −59.5]
rM2PP,y,i^c	[1 −1.80 0.022]	[−0.07 −0.00 −21.2]	[1 −1.84 0.034]	[−0.05 −0.01 −47.5]
rM2PPFIQ,y,i^c	[1 −1.71 0.017]	[−0.06 0.04 −15.4]	[1 −1.84 0.034]	[−0.02 −0.02 −35.6]
rM2PPALLQ,y,i^c	[1 −1.72 0.017]	[−0.06 0.04 −15.6]	[1 −1.95 0.036]	[−0.09 −0.01 −47.7]
rM3β,y,i^c	[1 −1.67 0.013]	[−0.15 −0.03 −16.6]	[1 −1.47 0.037]	[−0.07 −0.02 −25.3]
rLLβ,y,i^c	[1 −1.70 0.019]	[−0.15 −0.02 −15.6]	[1 −2.82 −0.026]	[−0.02 0.05 21.0]
rM5,y,i^c	[1 −1.73 0.042]	[−0.05 −0.04 −14.3]	[1 −2.71 −0.00]	[−0.04 0.04 12.6]

a. Sample for rM2PP through rM5 ends in 1996Q4.

Table 6
Restricted estimates of long-run money demand, 1970Q1–1998Q4

Variables	Order of VECM[a]	First CI vector	Corresponding loadings	Number of CI vectors[b]
rM2,y,i^c	3	[1 −1.39 0.023]	[−0.02* −0.03* −25.7*]	1
rM2P,y,i^c	3	[1 −1.54 0.022]	[−0.03* −0.02* −22.0*]	1
rM2PFIQ,y,i^c	3	[1 −1.64 0.020]	[−0.05* −0.02 −25.0*]	1
rM2PALLQ,y,i^c	3	[1 −1.84 0.039]	[−0.05* −0.02 −19.0*]	1
rM2P_Adj,y,i^c	3	[1 −1.46 0.015]	[−0.06* −0.00 −26.7*]	1
rM2PP_Adj,y,i^c	3	[1 −1.70 0.032]	[−0.05* −0.00 −17.9*]	1
rM2PP,y,i^c	3	[1 −1.71 0.023]	[−0.02 −0.02 −28.3*	1
rM2PPFIQ,y,i^c	3	[1 −1.73 0.017]	[−0.05* 0.01 −29.2*]	1
rM2PPALLQ,y,i^c	3	[1 −1.82 0.020]	[−0.06* 0.02 −30.9*]	1
rM3β,y,i^c	3	[1 −1.63 0.026]	[−0.08* −0.02 −22.1*]	1
rLLβ,y,i^c	3	[1 −1.73 0.019]	[−0.11* −0.01 −29.2*]	1
rM5,y,i^c	3	[1 −1.57 0.029]	[−0.07* −0.03 −23.0*]	1

Note: Sample for rM2PP through rM5 ends in 1996Q4.
a. VECM chosen on the basis of Akaike's FPE criterion.
b. According to Johansen-Juselius trace and λ-max statistics.
* Significant at the 5 per cent level.

demand function that is otherwise stable; evidently the financial innovations that plagued M2 are easily internalized. This does not necessarily imply that the dynamics around long-run money demand are stable, but the results in section 8, which looks at out-of-sample forecasts, do give some indication of dynamic stability.

6 The Effect of Broad Money on Prices

The Johansen-Juselius estimation results in Table 4 show that broad money has a significant effect on real balances, but the results do not identify whether that is because money falls or prices rise, or both, in response to a money gap. This section focuses on broad money's effect on prices.

The VECM in Table 4 contains a real balance equation of the form

$$A(L)\Delta(m-p) = C(L)\Delta y + D(L)\Delta i^c + Emgap + G(i^o - i^c). \tag{2}$$

In Table 7, I estimate a similar equation for prices:

$$\begin{aligned} A1(L)\Delta p = {} & A2(L)\Delta m + C^1(L)\Delta y + D^1(L)\Delta i^c + E^1 mgap \\ & + Fygap + G(i^o - i^c). \end{aligned} \tag{3}$$

M121

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Table 7
Price equations

	1970Q1–1998Q4			1970Q1–1984Q4			1982Q1–1998Q4[a]		
	$E^1=0$		$E^1, A2(l)=0$	$E^1=0$		$E^1, A2(l)=0$	$E^1=0$		$E^1, A2(l)=0$
	Coefficient	***t*-statistic**	**Significance level (%)**	**Coefficient**	***t*-statistic**	**Significance level (%)**	**Coefficient**	***t*-statistic**	**Significance level (%)**
M2	0.012	1.7	4.0	0.016	1.5	22.9	0.020	1.8	43.9
M2P	0.015	2.2	2.2	0.017	1.0	25.1	0.024	1.8	39.0
M2PFIQ	0.024	2.9	0.7	0.018	1.1	24.5	0.033	2.4	18.5
M2PALLQ	0.019	3.0	0.9	0.019	1.1	24.1	0.032	2.9	7.0
M2P_Adj	0.028	2.4	4.7	0.051	2.1	3.5	0.031	1.8	32.2
M2PP_Adj	0.030	3.2	1.3	0.050	2.1	3.4	0.041	2.9	7.8
M2PP	0.009	0.9	59.3	0.021	1.4	36.0	0.022	1.9	39.4
M2PPFIQ	0.021	1.5	17.7	0.038	2.0	2.3	0.027	1.7	47.6
M2PPALLQ	0.023	1.6	17.3	0.038	2.0	2.3	0.027	1.7	50.8
M3β	0.016	2.0	31.6	0.010	0.6	68.87	0.013	1.0	75.2
LLβ	0.024	2.2	22.5	0.011	0.7	73.7	0.057	2.4	21.3
M5	0.012	1.7	9.9	0.019	0.3	40.7	0.065	4.3	0.2

Note: Grey shading indicates models that produce significant *t*-statistics.

a. Sample for M2PP through M5 ends in 1996Q4.

Table 7
Price equations

	1970Q1–1998Q4			1970Q1–1984Q4			1982Q1–1998Q4[a]		
	$E^1=0$		$E^1, A2(l)=0$	$E^1=0$		$E^1, A2(l)=0$	$E^1=0$		$E^1, A2(l)=0$
	Coefficient	t-statistic	Significance level (%)	Coefficient	t-statistic	Significance level (%)	Coefficient	t-statistic	Significance level (%)
M2	0.012	1.7	4.0	0.016	1.5	22.9	0.020	1.8	43.9
M2P	0.015	2.2	2.2	0.017	1.0	25.1	0.024	1.8	39.0
M2PFIQ	0.024	2.9	0.7	0.018	1.1	24.5	0.033	2.4	18.5
M2PALLQ	0.019	3.0	0.9	0.019	1.1	24.1	0.032	2.9	7.0
M2P_Adj	0.028	2.4	4.7	0.051	2.1	3.5	0.031	1.8	32.2
M2PP_Adj	0.030	3.2	1.3	0.050	2.1	3.4	0.041	2.9	7.8
M2PP	0.009	0.9	59.3	0.021	1.4	36.0	0.022	1.9	39.4
M2PPFIQ	0.021	1.5	17.7	0.038	2.0	2.3	0.027	1.7	47.6
M2PPALLQ	0.023	1.6	17.3	0.038	2.0	2.3	0.027	1.7	50.8
M3β	0.016	2.0	31.6	0.010	0.6	68.87	0.013	1.0	75.2
LLβ	0.024	2.2	22.5	0.011	0.7	73.7	0.057	2.4	21.3
M5	0.012	1.7	9.9	0.019	0.3	40.7	0.065	4.3	0.2

Note: Grey shading indicates models that produce significant t-statistics.
a. Sample for M2PP through M5 ends in 1996Q4.

Equation (3) decomposes real balances into their components—prices and money—and adds an output gap. Data for the output gap are taken from the Bank of Canada's Quarterly Projection Model. The interest rate differential between the proxy for the own rate on broad money and the competing rate is also added to both equations (2) and (3) to remedy the fact that the own rate was dropped from calculation of the money gap. Put another way, if money demand depends on output, own, and competing interest rates, then two cointegrating vectors belong in the full VECM: one that can be formed by using the Johansen procedure on real balances, output, and competing interest rates; and a second that consists of the interest rate differential.[15] In economic terms the interest rate differential may have an effect both through its influence on long-run money demand and because of supply factors. This differential can be thought of as a proxy for the intermediation spread for banks (one of the components of the competing rate is the government bond rate). When the rate paid on deposits rises relative to other rates of return, banks may look for ways to encourage their clients to move into more-profitable lines by means other than interest rates—by raising service charges, for example. When this differential is high, bank profitability would be reduced, affecting their balance sheets and possibly having repercussions on bank deposits.

Testing for $E^1 > 0$ is a way of determining whether money gaps matter to the inflation process. Testing for $E^1 = 0$ and $A2(L) = 0$ is a way of testing whether broad money affects inflation through money growth or money gaps. The output gap is included in equation (3) because it is part of a competing model of price determination. Nesting the output gap within this model allows one to determine whether money matters even after the effect of the output gap is taken into account.

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[15] Along the lines of my discussion in note 12, the two structural cointegration vectors can be written

$$rm - a_1 y + a_5 i^c - a_3 di\,,$$

where

$$di = i^o - i^c \text{ and } a_5 = a_4 - a_3 \text{ and } a_2 = 0\,.$$

If we use the same argument as in note 12, all the parameters of the first structural cointegration vector are identified except a_3, the coefficient of the interest rate differential. Since that is an I(0) variable it can be dropped and the other parameters estimated consistently in the 3-variable system. However, in the VECM, or any dynamic equation such as (2), the system's second cointegration vector should be added back to the system, not only because it may be a significant variable in its own right, but also because it may be necessary to determine whether the money gap is significant.

Lagged changes in the interest rate differential could also be added to equation (3). However, these were not significant and worsened the equation fit.

In Table 7, the estimates of equation (3) are shown over the whole sample and over the subsamples 1970Q1–1984Q4 and 1982Q1–1998Q4. Over the entire sample most broad aggregates contribute significantly to inflation. In the subsamples the results are more mixed. Over the first subsample only a few aggregates contribute significantly to inflation; over the 1980s and 1990s, when the variance of inflation was much lower, almost all aggregates contribute significantly. The evidence shows that, overall, broad money contributes to inflation.

7 Restricted Price Equations

The ADF tests from Table 2 indicate that the price level is borderline I(2) and that several money aggregates appear to be I(2). The effect this has on the price equation can be seen in the following simple first-order version of equation (3):

$$\begin{aligned} \Delta p_t &= a\Delta p_{t-1} + b\Delta m_{t-1} + c\Delta y_{t-1} + d\Delta i_{t-1} + eMGAP_{t-1} \\ &\quad + fYGAP_{t-1} + g(i^o - i^c)_{t-1} + u_t . \end{aligned} \tag{4}$$

This can also be written

$$\begin{aligned} \Delta p_t - \Delta p_{t-1} &= (a + b - 1)\Delta p_{t-1} + b(\Delta m_{t-1} - \Delta p_{t-1}) + c\Delta y_{t-1} \\ &\quad + d\Delta i_{t-1} + eMGAP_{t-1} + fYGAP_{t-1} \\ &\quad + g(i^o - i^c)_{t-1} + u_t . \end{aligned} \tag{5}$$

In equation (5) all variables are stationary except the variable representing lagged price changes if prices are I(2). By imposing the constraint $a + b = 1$, that variable is eliminated from equation (5).

In the general case rather than the first-order system described in equation (5), the constraint involves imposing $A1(1) + A2(1) = 1$. When the restriction is true, one should expect little difference between the restricted and unrestricted estimates.

Estimates with this restriction are shown in Table 8. Again, over the entire sample period most broad aggregates contribute significantly to inflation. The same is true in the first subsample. However, in the second subsample none of the broad aggregates in this restricted version are significant. This is likely because in the second subperiod the inflation process changed; inflation was no longer a unit-root process.[16] For example, if economic agents gave some weight to the inflation targets in Canada in their expectations, coefficients on lagged money and prices would sum to

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[16] In fact, a unit-root test rejects a unit root in inflation over this period.

Table 8
Restricted price equations

	1970Q1–1998Q4[a]			1970Q1–1984Q4			1982Q1–1998Q4[a]		
	$E^1=0$		$E^1, A2(I)=0$	$E^1=0$		$E^1, A2(I)=0$	$E^1=0$		$E^1, A2(I)=0$
	Coefficient	***t*-statistic**	**Significance level (%)**	**Coefficient**	***t*-statistic**	**Significance level (%)**	**Coefficient**	***t*-statistic**	**Significance level (%)**
M2	0.001	0.3	6.2	0.015	1.2	4.9	0.000	0.0	82.6
M2P	0.006	0.9	6.6	0.024	1.4	3.3	0.000	0.0	84.2
M2PFIQ	0.015	1.8	1.9	0.025	1.5	3.3	0.003	0.3	69.4
M2PALLQ	0.014	2.1	0.5	0.027	1.5	3.1	0.011	1.1	32.2
M2P_Adj	0.024	2.0	8.3	0.060	2.4	0.5	–0.007	–0.4	84.9
M2PP_Adj	0.019	2.0	2.0	0.060	2.4	0.5	0.008	0.6	42.8
M2PP	0.001	0.1	76.0	0.027	1.8	2.3	–0.005	–0.5	90.9
M2PPFIQ	0.020	1.4	19.4	0.048	2.7	0.1	–0.006	–0.5	94.5
M2PPALLQ	0.031	2.3	2.6	0.047	2.7	0.1	–0.003	–0.2	97.3
M3β	0.015	1.7	22.7	0.021	1.2	62.7	0.018	1.3	52.0
LLβ	0.023	2.1	13.2	0.027	1.5	47.3	–0.010	–0.7	70.0
M5	0.010	1.4	3.3	0.004	0.5	26.8	0.005	0.5	34.1

Note: Grey shading indicates models that produce significant *t*-statistics.

a. Sample for M2PP through M5 ends in 1996Q4

Table 8
Restricted price equations

	1970Q1–1998Q4[a]			1970Q1–1984Q4			1982Q1–1998Q4[a]		
	$E^1=0$		$E^1, A2(1)=0$	$E^1=0$		$E^1, A2(1)=0$	$E^1=0$		$E^1, A2(1)=0$
	Coefficient	*t*-statistic	Significance level (%)	Coefficient	*t*-statistic	Significance level (%)	Coefficient	*t*-statistic	Significance level (%)
M2	0.001	0.3	6.2	0.015	1.2	4.9	0.000	0.0	82.6
M2P	0.006	0.9	6.6	0.024	1.4	3.3	0.000	0.0	84.2
M2PFIQ	0.015	1.8	1.9	0.025	1.5	3.3	0.003	0.3	69.4
M2PALLQ	0.014	2.1	0.5	0.027	1.5	3.1	0.011	1.1	32.2
M2P_Adj	0.024	2.0	8.3	0.060	2.4	0.5	–0.007	–0.4	84.9
M2PP_Adj	0.019	2.0	2.0	0.060	2.4	0.5	0.008	0.6	42.8
M2PP	0.001	0.1	76.0	0.027	1.8	2.3	–0.005	–0.5	90.9
M2PPFIQ	0.020	1.4	19.4	0.048	2.7	0.1	–0.006	–0.5	94.5
M2PPALLQ	0.031	2.3	2.6	0.047	2.7	0.1	–0.003	–0.2	97.3
M3β	0.015	1.7	22.7	0.021	1.2	62.7	0.018	1.3	52.0
LLβ	0.023	2.1	13.2	0.027	1.5	47.3	–0.010	–0.7	70.0
M5	0.010	1.4	3.3	0.004	0.5	26.8	0.005	0.5	34.1

Note: Grey shading indicates models that produce significant *t*-statistics.

a. Sample for M2PP through M5 ends in 1996Q4.

less than 1. If this were the case, the need for the restriction would disappear and the results of Table 7, with no restriction, would be appropriate. One indication that the restriction is not appropriate over this latter period is that the output gap, a variable that tends to be reliably associated with future inflation, also becomes insignificant in the price equation over this subsample. Consequently, the fact that broad money does not predict inflation in this subsample specification likely does not mean that broad money has become less informative; rather it reflects the inappropriateness of the restriction for this subsample. When the restriction is removed, broad money continues to predict inflation during the 1980s and 1990s.

8 Recursive VECM Indicators

The recursive VECM methodology is a way of mimicking how accurately forecasters would have predicted inflation had they used the VECM approach to first estimate long-run money demand and then forecast inflation. Unlike the within-sample methodology, which uses a single equation such as (3) to assess whether money matters, the recursive VECM methodology relies on assessing out-of-sample system forecasts. Thus the results could be very different. Using this methodology, I initially estimated long-run money demand in the manner used in Table 4 for the sample period 1970Q1 to 1974Q2. The residuals of this vector are added to a vector autoregression (VAR) in first differences for m, p, y, and i^c. Inflation forecasts of the form

$$\frac{400}{k}\Delta_k p \; k=1,2,4,8 \tag{6}$$

are made for observations 1974Q3 to 1976Q2. The forecast errors of these inflation forecasts are calculated. The sample is extended by one observation to 1974Q3. Long-run money demand, price forecasts, and forecast errors are recalculated, and so on until the last observation exhausts the data.

Root-mean-squared errors (RMSEs) are calculated for four different horizons: 1, 2, 4, and 8 quarters. From a monetary policy perspective the 4- and 8-quarter horizons are the most interesting because it takes that long for current monetary policy actions to affect prices; thus a price forecast that looks ahead 4 to 8 quarters is useful for determining what policy actions should be taken today. When calculating the RMSEs, I ignored the first 20 observations because they correspond to samples with very few degrees of freedom and therefore are potentially unreliable forecasts. For the 1970Q1–1998Q4 results the first simulation period used for the RMSE calculation will be 1979Q2.

M121

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Table 9

Recursive VECMs for price-inflation-forecast RMSEs (percentage)

		Horizon				Horizon				Horizon			
		1	2	4	8	1	2	4	8	1	2	4	8
		1970Q1–1998Q4				1970Q1–1984Q4				1982Q1–1998Q4			
No money		1.94	1.86	1.96	2.26	3.25	3.11	2.96	2.69	1.54	1.43	1.46	2.31
M2	No money gap	2.01	1.88	1.70	1.80	3.65	3.41	2.79	2.45	1.63	1.39	1.25	1.03
	With money gap	1.97	1.84	1.87	1.95	3.44	3.16	3.05	2.51	1.56	1.33	1.19	1.30
M2P	No money gap	2.04	1.94	1.71	1.70	3.75	3.54	2.86	2.39	1.70	1.43	1.27	1.04
	With money gap	2.02	1.88	1.82	1.91	3.58	3.28	3.09	2.86	1.64	1.39	1.24	1.38
M2PFIQ	No money gap	2.05	1.95	1.73	1.72	3.75	3.53	2.86	2.40	1.68	1.43	1.25	1.15
	With money gap	2.05	1.91	1.86	1.96	3.58	3.27	3.08	2.87	1.37	1.40	1.24	1.49
M2PALLQ	No money gap	2.06	1.98	1.78	1.89	3.75	3.54	2.86	2.40	1.67	1.40	1.24	1.49
	With money gap	2.07	1.96	1.93	2.08	3.59	3.28	3.07	2.86	1.72	1.53	1.39	1.71
M2P_Adj	No money gap	1.94	1.83	1.61	1.64	3.48	3.33	2.94	2.69	1.70	1.43	1.12	1.08
	With money gap	1.98	1.80	1.64	1.52	3.33	2.93	2.46	1.49	1.63	1.37	1.07	1.20
M2PP_Adj	No money gap	1.94	1.86	1.96	2.26	3.48	3.33	2.95	2.69	1.74	1.53	1.32	1.33
	With money gap	1.95	1.85	1.64	1.72	3.33	2.92	2.46	1.47	1.70	1.52	1.27	1.43
		1970Q1–96Q4				1970Q1–1984Q4				1982Q1–1996Q4			
No money		2.07	1.96	2.05	2.32	3.25	3.11	2.96	2.69	1.93	1.70	1.69	2.69
M2PP	No money gap	2.14	2.06	1.88	1.89	3.63	2.51	2.89	2.28	2.27	1.86	1.78	1.74
	With money gap	2.18	2.05	1.94	1.94	3.50	3.46	2.57	1.91	2.07	1.65	1.42	1.46
M2PPFIQ	No money gap	2.17	2.07	1.88	1.86	3.44	3.43	2.87	2.24	2.17	1.84	1.71	1.74
	With money gap	2.25	2.10	1.99	1.92	3.38	3.06	2.55	1.81	1.98	1.64	1.42	1.50
M2PPALLQ	No money gap	2.16	2.07	1.85	1.85	3.43	3.42	2.87	2.25	2.17	1.83	1.67	1.75
	With money gap	2.25	2.11	1.99	1.92	3.37	3.05	2.55	1.83	1.97	1.65	1.41	1.52
M3β	No money gap	2.06	1.92	1.83	2.08	3.55	3.35	2.94	2.71	2.22	1.83	1.73	1.74
	With money gap	2.13	2.01	2.04	2.10	3.28	2.91	2.51	1.99	2.11	1.78	1.62	1.99
LLβ	No money gap	2.05	1.90	1.77	1.90	3.56	3.35	2.90	2.64	2.24	1.85	1.65	1.60
	With money gap	2.12	1.99	1.97	1.98	3.29	2.92	2.52	2.02	2.15	1.81	1.54	1.85
M5	No money gap	2.01	1.82	1.63	1.86	3.44	3.16	2.63	2.19	2.21	1.76	1.61	1.62
	With money gap	2.07	1.90	1.87	1.95	3.26	2.89	2.59	1.85	2.13	1.75	1.51	2.01

Note: Grey shading indicates models that produce lower RMSEs than the base model that excludes money.

Table 9

Recursive VECMs for price-inflation-forecast RMSEs (percentage)

		Horizon				Horizon				Horizon			
		1	2	4	8	1	2	4	8	1	2	4	8
		1970Q1–1998Q4				1970Q1–1984Q4				1982Q1–1998Q4			
No money		1.94	1.86	1.96	2.26	3.25	3.11	2.96	2.69	1.54	1.43	1.46	2.31
M2	No money gap	2.01	1.88	1.70	1.80	3.65	3.41	2.79	2.45	1.63	1.39	1.25	1.03
	With money gap	1.97	1.84	1.87	1.95	3.44	3.16	3.05	2.51	1.56	1.33	1.19	1.30
M2P	No money gap	2.04	1.94	1.71	1.70	3.75	3.54	2.86	2.39	1.70	1.43	1.27	1.04
	With money gap	2.02	1.88	1.82	1.91	3.58	3.28	3.09	2.86	1.64	1.39	1.24	1.38
M2PFIQ	No money gap	2.05	1.95	1.73	1.72	3.75	3.53	2.86	2.40	1.68	1.43	1.25	1.15
	With money gap	2.05	1.91	1.86	1.96	3.58	3.27	3.08	2.87	1.37	1.40	1.24	1.49
M2PALLQ	No money gap	2.06	1.98	1.78	1.89	3.75	3.54	2.86	2.40	1.67	1.40	1.24	1.49
	With money gap	2.07	1.96	1.93	2.08	3.59	3.28	3.07	2.86	1.72	1.53	1.39	1.71
M2P_Adj	No money gap	1.94	1.83	1.61	1.64	3.48	3.33	2.94	2.69	1.70	1.43	1.12	1.08
	With money gap	1.98	1.80	1.64	1.52	3.33	2.93	2.46	1.49	1.63	1.37	1.07	1.20
M2PP_Adj	No money gap	1.94	1.86	1.96	2.26	3.48	3.33	2.95	2.69	1.74	1.53	1.32	1.33
	With money gap	1.95	1.85	1.64	1.72	3.33	2.92	2.46	1.47	1.70	1.52	1.27	1.43
		1970Q1–96Q4				1970Q1–1984Q4				1982Q1–1996Q4			
No money		2.07	1.96	2.05	2.32	3.25	3.11	2.96	2.69	1.93	1.70	1.69	2.69
M2PP	No money gap	2.14	2.06	1.88	1.89	3.63	2.51	2.89	2.28	2.27	1.86	1.78	1.74
	With money gap	2.18	2.05	1.94	1.94	3.50	3.46	2.57	1.91	2.07	1.65	1.42	1.46
M2PPFIQ	No money gap	2.17	2.07	1.88	1.86	3.44	3.43	2.87	2.24	2.17	1.84	1.71	1.74
	With money gap	2.25	2.10	1.99	1.92	3.38	3.06	2.55	1.81	1.98	1.64	1.42	1.50
M2PPALLQ	No money gap	2.16	2.07	1.85	1.85	3.43	3.42	2.87	2.25	2.17	1.83	1.67	1.75
	With money gap	2.25	2.11	1.99	1.92	3.37	3.05	2.55	1.83	1.97	1.65	1.41	1.52
M3β	No money gap	2.06	1.92	1.83	2.08	3.55	3.35	2.94	2.71	2.22	1.83	1.73	1.74
	With money gap	2.13	2.01	2.04	2.10	3.28	2.91	2.51	1.99	2.11	1.78	1.62	1.99
LLβ	No money gap	2.05	1.90	1.77	1.90	3.56	3.35	2.90	2.64	2.24	1.85	1.65	1.60
	With money gap	2.12	1.99	1.97	1.98	3.29	2.92	2.52	2.02	2.15	1.81	1.54	1.85
M5	No money gap	2.01	1.82	1.63	1.86	3.44	3.16	2.63	2.19	2.21	1.76	1.61	1.62
	With money gap	2.07	1.90	1.87	1.95	3.26	2.89	2.59	1.85	2.13	1.75	1.51	2.01

Note: Grey shading indicates models that produce lower RMSEs than the base model that excludes money.

Three different sets of VARs or VECMs are compared. The first excludes money entirely and consists of a VAR in first differences for *p, y,* and i^c. The second includes money growth and consists of a VAR in first differences for *m, p, y,* and i^c. The third consists of a VECM that includes both money growth and money gaps; that is, a VAR in first differences for *m, p, y,* and i^c augmented by the residuals from estimates of the long-run money-demand function. In Table 9, estimates are shown for the full sample 1970Q1–1998Q4 and for two subsamples, 1970Q1–1984Q4 and 1982Q1–1998Q4.

Rather than use the 4-variable system of *m, p, y,* and i^c as the basis for forecasting inflation, it might seem preferable to use the 5-variable system of *m, p, y,* i^c, and *di* (*di* being the interest rate differential used in section 6) to estimate the effect of money on inflation. The same arguments made in section 6 for including the interest rate differential apply here when making out-of-sample VECM forecasts. However, the 5-variable system fared poorly compared with the 4-variable system without the interest rate differential, posting less-accurate inflation forecasts across the board. Consequently, I present the results from the more parsimonious 4-variable system.

For the full sample (see Table 9), broad money would have reduced inflation-forecast errors for 4- and 8-quarter-ahead forecasts using any definition of broad money. Reductions of up to 20 to 30 per cent occurred. For shorter forecast horizons, M2P_Adj and M2PP_Adj help reduce inflation-forecast errors, as do the broader aggregates M3β, LLβ, and M5. Over the 1970Q1–1984Q4 period, money reduces inflation errors for 4- and 8-quarter-ahead forecasts for all measures of broad money as well as 2-quarter-ahead forecasts for M2P_Adj, M2PP_Adj, and the broader measures of money. Over the 1982Q1–1996Q4 subsample, broad money is again important at all 4- and 8-quarter horizons and also for some of the narrower measures of broad money at 2-quarter horizons. In summary, broad money helps reduce inflation-forecast errors, especially at 4- and 8-quarter horizons for all measures of broad money, and over both subsamples as well as over the full sample period.

As in the price equations estimated in Table 8, the short-run dynamics of the VARs and VECMs are next restricted to take into account possible nonstationarity of some of the data. In the money and price equations the coefficients of lagged money and lagged prices are constrained to sum to 1. In the output and interest rate equations the money effects and the price effects are constrained to sum to 0. Restricted estimates are shown in Table 10. The results are broadly similar to those of Table 9, which had no restrictions. Broad money does best at 4- and 8-quarter horizons. The results

Table 10

Restricted recursive VECMs for price-inflation-forecast RMSEs (percentage)

		1970Q1–1998Q4				1970Q1–1984Q4				1982Q1–1998Q4			
		Horizon				Horizon				Horizon			
		1	2	4	8	1	2	4	8	1	2	4	8
No money		1.94	1.84	1.87	2.03	3.24	3.08	2.92	2.98	1.54	1.40	1.42	2.22
M2	No money gap	2.04	1.95	1.85	1.98	3.65	3.39	2.78	2.63	1.72	1.51	1.47	1.52
	With money gap	2.05	1.97	2.06	2.13	3.47	3.26	3.28	2.99	1.65	1.48	1.53	1.56
M2P	No money gap	2.04	1.98	1.86	2.03	3.93	3.52	2.83	2.44	1.80	1.58	1.55	1.56
	With money gap	2.10	2.03	2.06	2.23	3.63	3.42	3.34	3.15	1.93	1.53	1.55	1.71
M2PFIQ	No money gap	2.04	1.97	1.82	1.93	3.93	3.52	2.82	2.46	1.76	1.52	1.41	1.33
	With money gap	2.10	2.02	2.04	2.14	3.63	3.41	3.34	3.16	1.41	1.54	1.46	1.54
M2PALLQ	No money gap	2.03	1.96	1.78	1.85	3.73	3.52	2.82	2.47	1.72	1.49	1.31	1.11
	With money gap	2.09	2.01	2.00	2.07	3.64	3.42	3.34	3.16	1.67	1.44	1.31	1.43
M2P_Adj	No money gap	1.94	1.84	1.65	1.70	3.46	3.31	2.89	2.59	1.85	1.66	1.57	1.57
	With money gap	2.00	1.88	1.71	1.67	3.32	2.95	2.65	2.27	1.81	1.65	1.57	1.68
M2PP_Adj	No money gap	1.93	1.82	1.58	1.57	3.46	3.31	2.89	2.60	1.78	1.57	1.35	1.19
	With money gap	1.98	1.83	1.62	1.53	3.32	2.90	2.66	2.28	1.73	1.54	1.34	1.41
		1970Q1–1996Q4				1970Q1–1984Q4				1982Q1–1996Q4			
No money		2.07	1.94	1.96	2.13	3.24	3.08	2.92	2.98	1.89	1.63	1.59	2.59
M2PP	No money gap	2.16	2.12	2.00	1.99	3.61	93.5	2.87	2.10	2.34	1.97	1.87	2.01
	With money gap	2.21	2.12	1.98	1.99	3.53	3.24	3.65	2.05	2.12	1.75	1.89	2.35
M2PPFIQ	No money gap	2.17	2.09	1.91	1.85	3.44	3.42	2.81	1.93	2.22	1.94	1.78	1.90
	With money gap	2.23	2.11	1.91	1.83	3.41	3.19	2.61	1.79	2.06	1.82	1.89	2.34
M2PPALLQ	No money gap	2.15	2.05	1.80	1.68	3.43	3.41	2.81	1.92	2.21	1.89	1.57	1.52
	With money gap	2.21	2.07	1.81	1.65	3.41	3.20	2.61	1.74	2.09	1.83	1.76	2.10
M3β	No money gap	2.05	1.88	1.69	1.67	3.53	3.25	2.67	2.27	2.24	1.82	1.55	1.04
	With money gap	2.08	1.93	1.94	2.17	3.40	3.17	3.15	3.52	2.13	1.74	1.49	1.40
LLβ	No money gap	2.04	1.87	1.66	1.59	3.53	3.26	2.65	2.16	2.26	1.85	1.52	1.26
	With money gap	2.07	1.92	1.90	2.08	3.40	3.19	3.13	3.40	2.13	1.76	1.48	1.48
M5	No money gap	2.00	1.78	1.54	1.48	3.42	3.09	2.50	2.09	2.19	1.71	1.35	0.80
	With money gap	2.02	1.81	1.76	1.94	3.25	2.95	2.86	3.09	2.11	1.67	1.33	1.10

Note: Grey shading indicates models that produce lower RMSEs than the base model that excludes money.

Table 10

Restricted recursive VECMs for price-inflation-forecast RMSEs (percentage)

		1970Q1–1998Q4				1970Q1–1984Q4				1982Q1–1998Q4			
		Horizon				Horizon				Horizon			
		1	2	4	8	1	2	4	8	1	2	4	8
No money		1.94	1.84	1.87	2.03	3.24	3.08	2.92	2.98	1.54	1.40	1.42	2.22
M2	No money gap	2.04	1.95	1.85	1.98	3.65	3.39	2.78	2.63	1.72	1.51	1.47	1.52
	With money gap	2.05	1.97	2.06	2.13	3.47	3.26	3.28	2.99	1.65	1.48	1.53	1.56
M2P	No money gap	2.04	1.98	1.86	2.03	3.93	3.52	2.83	2.44	1.80	1.58	1.55	1.56
	With money gap	2.10	2.03	2.06	2.23	3.63	3.42	3.34	3.15	1.93	1.53	1.55	1.71
M2PFIQ	No money gap	2.04	1.97	1.82	1.93	3.93	3.52	2.82	2.46	1.76	1.52	1.41	1.33
	With money gap	2.10	2.02	2.04	2.14	3.63	3.41	3.34	3.16	1.41	1.54	1.46	1.54
M2PALLQ	No money gap	2.03	1.96	1.78	1.85	3.73	3.52	2.82	2.47	1.72	1.49	1.31	1.11
	With money gap	2.09	2.01	2.00	2.07	3.64	3.42	3.34	3.16	1.67	1.44	1.31	1.43
M2P_Adj	No money gap	1.94	1.84	1.65	1.70	3.46	3.31	2.89	2.59	1.85	1.66	1.57	1.57
	With money gap	2.00	1.88	1.71	1.67	3.32	2.95	2.65	2.27	1.81	1.65	1.57	1.68
M2PP_Adj	No money gap	1.93	1.82	1.58	1.57	3.46	3.31	2.89	2.60	1.78	1.57	1.35	1.19
	With money gap	1.98	1.83	1.62	1.53	3.32	2.90	2.66	2.28	1.73	1.54	1.34	1.41
		1970Q1–1996Q4				1970Q1–1984Q4				1982Q1–1996Q4			
No money		2.07	1.94	1.96	2.13	3.24	3.08	2.92	2.98	1.89	1.63	1.59	2.59
M2PP	No money gap	2.16	2.12	2.00	1.99	3.61	93.5	2.87	2.10	2.34	1.97	1.87	2.01
	With money gap	2.21	2.12	1.98	1.99	3.53	3.24	3.65	2.05	2.12	1.75	1.89	2.35
M2PPFIQ	No money gap	2.17	2.09	1.91	1.85	3.44	3.42	2.81	1.93	2.22	1.94	1.78	1.90
	With money gap	2.23	2.11	1.91	1.83	3.41	3.19	2.61	1.79	2.06	1.82	1.89	2.34
M2PPALLQ	No money gap	2.15	2.05	1.80	1.68	3.43	3.41	2.81	1.92	2.21	1.89	1.57	1.52
	With money gap	2.21	2.07	1.81	1.65	3.41	3.20	2.61	1.74	2.09	1.83	1.76	2.10
M3β	No money gap	2.05	1.88	1.69	1.67	3.53	3.25	2.67	2.27	2.24	1.82	1.55	1.04
	With money gap	2.08	1.93	1.94	2.17	3.40	3.17	3.15	3.52	2.13	1.74	1.49	1.40
LLβ	No money gap	2.04	1.87	1.66	1.59	3.53	3.26	2.65	2.16	2.26	1.85	1.52	1.26
	With money gap	2.07	1.92	1.90	2.08	3.40	3.19	3.13	3.40	2.13	1.76	1.48	1.48
M5	No money gap	2.00	1.78	1.54	1.48	3.42	3.09	2.50	2.09	2.19	1.71	1.35	0.80
	With money gap	2.02	1.81	1.76	1.94	3.25	2.95	2.86	3.09	2.11	1.67	1.33	1.10

Note: Grey shading indicates models that produce lower RMSEs than the base model that excludes money.

also indicate that, contrary to the U.S. case (see Estrella and Mishkin 1996), broad money has remained a useful indicator of inflation since the 1980s.

9 The Source of the Information in Broad Money

The results discussed above show that broad money helps to forecast inflation even after output and interest rates are taken into account. But is it possible that broad money helps to forecast inflation only because it contains narrow money, which has been shown to be a leading indicator of inflation at long horizons? This section tests that hypothesis in two ways: by estimating recursive VECMs for broad-money aggregates from which narrow money has been removed and by comparing broad-money VECM forecasts to those of narrow money.

Three measures of narrow money are considered. The first is the conventional aggregate M1;[17] the second is M1_Adj, which adjusts recent data for M1 for shifts due to financial innovation and the elimination of reserve requirements; and the third is M1++, which adds chequable and non-chequable notice deposits to M1 and so internalizes some of the shifts between M1 and notice deposits that have occurred over the last 20 years. M1 was for a long time the Bank of Canada's preferred measure of narrow money, but recent instability has prompted the Bank to consider other narrow aggregates, such as M1_Adj and M1++.

The long-run money-demand functions are little changed by excluding narrow money, as is shown in Table 11. Income elasticities tend to be higher, as would be expected when excluding a component that is inelastic. Table 12 shows the results of recursive VECMs for broad money excluding M1. (Results that I have not shown are similar if M1_Adj or M1++, rather than M1, is excluded from broad money.) In general, RMSEs are a bit higher when narrow money is excluded, suggesting that both narrow and broad money contribute to forecasting inflation. But RMSEs do not increase drastically when narrow money is excluded, as we would expect if all of the forecasting power in broad money had been coming from its narrow-money component. And finally, comparing recursive VECM RMSEs for M1, M1_Adj, and M1++ to those of broad money (Table 10) or to those of broad money excluding M1 or M1_Adj (Table 12) shows that forecasts of inflation at various horizons made using several measures of broad money would have been more accurate over the various sample periods than forecasts made using narrow money. For example, for the full sample, both M2P_Adj and M2PP_Adj have lower RMSEs at 1-, 2-, 4-, and 8-quarter horizons compared with any of the narrow aggregates tested here.

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[17] M1 includes currency, personal chequing accounts, and current accounts.

Table 11
Restricted estimates of long-run money demand for broad money excluding M1Adj, 1970Q1 to 1998Q4

Variables	Order of VECM	First CI vector	Corresponding loadings	Number of CI vectors[a]
rM2,y,i^c	4	[1 −1.88 0.056]	[−0.00 −0.01 −11.9*]	1
rM2P,y,i^c	4	[1 −1.82 0.042]	[−0.01 −0.02* −14.4*]	1
rM2PFIQ,y,i^c	4	[1 −1.90 0.023]	[−0.03* −0.02* −23.8*]	1
rM2PALLQ,y,i^c	4	[1 −2.15 0.032]	[−0.04* −0.02 −24.3*]	1
rM2P_Adj,y,i^c	4	[1 −1.61 0.020]	[−0.03* −0.01 −21.3*]	1
rM2PP_Adj,y,i^c	4	[1 −1.93 0.023]	[−0.04 0.00 −38.2*]	1
rM2PP,y,i^c	4	[1 −2.06 0.041]	[−0.02 −0.01 −15.9*]	1
rM2PPFIQ,y,i^c	4	[1 −1.97 0.021]	[−0.02* 0.00 −25.8*]	1
rM2PPALLQ,y,i^c	4	[1 −2.07 0.020]	[−0.04* 0.02 −28.9*]	1
rM3β,y,i^c	4	[1 −1.80 0.023]	[−0.08* −0.02 −22.0*]	1
rLLβ,y,i^c	4	[1 −1.91 0.017]	[−0.11* −0.01 −27.7*]	1
rM5,y,i^c	4	[1 −1.70 0.029]	[−0.06* −0.03* −22.4*]	1

Note: Sample for *r*M2PP through *r*M5 ends in 1996Q4.
a. According to Johansen-Juselius trace and λ -max statistics.
b. VECM chosen on the basis of Akaike's FPE criterion.
* Significant at the 5 per cent level.

10 Narrowing the Broad-Money Aggregates

The above results demonstrate that many of the broad-money measures used here have stable money-demand functions and help to forecast inflation. Some of them can, however, be ruled out as useful measures of broad money for policy because they fail a number of tests. For example, M3β and LLβ, expressed in real terms, are found to be I(2), although in several cases they are only borderline I(2). The power of unit-root tests is low and so these series may indeed be I(1), but they do call into question the results of the long-run money-demand function estimation.

Of the broad aggregates that remain, M5, which generally produces among the most accurate inflation forecasts, does not have a long-run demand function that is particularly stable over the 1980s and 1990s. So given the criteria presented in the introduction, it, too, would be ruled out as a useful aggregate.

The remaining aggregates that consistently produce the most reliable forecasts are M2P_Adj and M2PP_Adj—that is, M2P with CSBs and mutual funds. These aggregates produce some of the best inflation forecasts and they also have stable demand functions over the last 30 years.

Table 12

Restricted recursive VECMs for price-inflation-forecast RMSEs (percentage), broad money excluding M1

		Horizon				Horizon				Horizon			
		1	2	4	8	1	2	4	8	1	2	4	8
		1970Q1–1998Q4				1970Q1–1984Q4				1982Q1–1998Q4			
No money		1.94	1.84	1.87	2.03	3.24	3.08	2.92	2.98	1.54	1.40	1.42	2.22
M2	No money gap	1.97	1.91	1.94	2.20	3.52	3.42	3.37	3.89	1.77	1.51	1.53	1.69
	With money gap	1.96	1.92	2.19	2.50	3.31	3.26	3.78	4.32	1.69	1.51	1.64	1.68
M2P	No money gap	2.01	1.94	1.89	2.10	3.59	3.39	3.01	3.21	1.86	1.63	1.64	1.74
	With money gap	1.99	1.92	2.12	2.57	3.36	3.18	3.55	4.36	1.80	1.60	1.67	1.81
M2PFIQ	No money gap	2.01	1.93	1.85	2.01	3.59	3.39	3.01	3.21	1.81	1.56	1.48	1.48
	With money gap	1.99	1.91	2.08	2.50	3.36	3.18	3.54	4.37	1.78	1.55	1.52	1.62
M2PALLQ	No money gap	2.00	1.91	1.80	1.92	3.60	3.39	3.01	3.19	1.74	1.50	1.33	1.22
	With money gap	1.99	1.89	2.03	2.42	3.37	3.18	3.53	4.37	1.68	1.43	1.32	1.41
M2P_Adj	No money gap	1.95	1.85	1.72	1.89	3.41	3.23	2.79	2.78	1.86	1.67	1.63	1.72
	With money gap	1.96	1.79	1.68	1.83	3.24	2.92	2.74	2.96	1.71	1.64	1.49	1.59
M2PP_Adj	No money gap	1.93	1.80	1.61	1.71	3.40	3.23	2.79	2.78	1.79	1.57	1.38	1.34
	With money gap	1.96	1.79	1.68	1.83	3.24	2.92	2.74	2.93	1.71	1.64	1.49	1.59
		1970Q1–1996Q4				1970Q1–1984Q4				1982Q1–1996Q4			
No money		2.07	1.94	1.96	2.13	3.24	3.08	2.92	2.98	1.89	1.63	1.59	2.59
M2PP	No money gap	2.16	2.12	2.02	2.04	3.61	3.43	2.80	2.17	2.31	1.95	1.85	2.05
	With money gap	2.20	2.11	2.03	2.11	3.50	3.18	2.66	2.41	2.01	1.69	1.64	1.95
M2PPFIQ	No money gap	2.20	2.09	1.95	1.97	3.41	3.37	2.75	1.94	2.22	1.92	1.81	2.04
	With money gap	2.26	2.11	1.97	1.97	3.36	3.11	2.49	1.83	2.03	1.74	1.70	2.03
M2PPALLQ	No money gap	2.17	2.04	1.84	1.77	3.40	3.36	2.74	1.92	2.20	1.90	1.62	1.71
	With money gap	2.23	2.07	1.87	1.78	3.35	3.10	2.49	1.84	2.04	1.75	1.65	1.83

(continued)

Table 12
Restricted recursive VECMs for price-inflation-forecast RMSEs (percentage), broad money excluding M1

		Horizon				Horizon				Horizon			
		1	2	4	8	1	2	4	8	1	2	4	8
		1970Q1–1998Q4				1970Q1–1984Q4				1982Q1–1998Q4			
No money		1.94	1.84	1.87	2.03	3.24	3.08	2.92	2.98	1.54	1.40	1.42	2.22
M2	No money gap	1.97	1.91	1.94	2.20	3.52	3.42	3.37	3.89	1.77	1.51	1.53	1.69
	With money gap	1.96	1.92	2.19	2.50	3.31	3.26	3.78	4.32	1.69	1.51	1.64	1.68
M2P	No money gap	2.01	1.94	1.89	2.10	3.59	3.39	3.01	3.21	1.86	1.63	1.64	1.74
	With money gap	1.99	1.92	2.12	2.57	3.36	3.18	3.55	4.36	1.80	1.60	1.67	1.81
M2PFIQ	No money gap	2.01	1.93	1.85	2.01	3.59	3.39	3.01	3.21	1.81	1.56	1.48	1.48
	With money gap	1.99	1.91	2.08	2.50	3.36	3.18	3.54	4.37	1.78	1.55	1.52	1.62
M2PALLQ	No money gap	2.00	1.91	1.80	1.92	3.60	3.39	3.01	3.19	1.74	1.50	1.33	1.22
	With money gap	1.99	1.89	2.03	2.42	3.37	3.18	3.53	4.37	1.68	1.43	1.32	1.41
M2P_Adj	No money gap	1.95	1.85	1.72	1.89	3.41	3.23	2.79	2.78	1.86	1.67	1.63	1.72
	With money gap	1.96	1.79	1.68	1.83	3.24	2.92	2.74	2.96	1.71	1.64	1.49	1.59
M2PP_Adj	No money gap	1.93	1.80	1.61	1.71	3.40	3.23	2.79	2.78	1.79	1.57	1.38	1.34
	With money gap	1.96	1.79	1.68	1.83	3.24	2.92	2.74	2.93	1.71	1.64	1.49	1.59
		1970Q1–1996Q4				1970Q1–1984Q4				1982Q1–1996Q4			
No money		2.07	1.94	1.96	2.13	3.24	3.08	2.92	2.98	1.89	1.63	1.59	2.59
M2PP	No money gap	2.16	2.12	2.02	2.04	3.61	3.43	2.80	2.17	2.31	1.95	1.85	2.05
	With money gap	2.20	2.11	2.03	2.11	3.50	3.18	2.66	2.41	2.01	1.69	1.64	1.95
M2PPFIQ	No money gap	2.20	2.09	1.95	1.97	3.41	3.37	2.75	1.94	2.22	1.92	1.81	2.04
	With money gap	2.26	2.11	1.97	1.97	3.36	3.11	2.49	1.83	2.03	1.74	1.70	2.03
M2PPALLQ	No money gap	2.17	2.04	1.84	1.77	3.40	3.36	2.74	1.92	2.20	1.90	1.62	1.71
	With money gap	2.23	2.07	1.87	1.78	3.35	3.10	2.49	1.84	2.04	1.75	1.65	1.83

(continued)

Table 12 (continued)
Restricted recursive VECMs for price-inflation-forecast RMSE (percentage), broad money excluding M1

		Horizon				Horizon				Horizon			
		1	**2**	**4**	**8**	**1**	**2**	**4**	**8**	**1**	**2**	**4**	**8**
		1970Q1–1996Q4				**1970Q1–1984Q4**				**1982Q1–1996Q4**			
M3β	No money gap	2.05	1.88	1.73	1.77	3.53	3.24	2.72	2.51	2.24	1.83	1.55	1.10
	With money gap	2.06	1.89	1.90	2.19	3.35	3.06	3.00	3.50	2.13	1.75	1.52	1.45
LLβ	No money gap	2.04	1.88	1.71	1.71	3.53	3.24	2.70	2.42	2.26	1.86	1.53	1.37
	With money gap	2.05	1.88	1.87	2.08	3.34	3.06	2.93	3.30	2.17	1.80	1.55	1.54
M5	No money gap	2.01	1.80	1.57	1.54	3.43	3.10	2.53	2.22	2.19	1.70	1.33	0.84
	With money gap	2.02	1.80	1.78	2.00	2.66	2.49	2.56	3.27	2.10	1.65	1.31	1.10
		1970Q1–1998Q4				**1970Q1–1984Q4**				**1982Q1–1998Q4**			
M1	No money gap	1.98	1.93	1.84	2.01	3.62	3.44	2.89	2.53	1.67	1.55	1.47	1.29
M1_Adj	No money gap	1.97	1.89	1.82	1.97	3.62	3.44	2.89	2.53	1.65	1.49	1.40	1.20
M1PP	No money gap	2.02	1.91	1.85	1.98	3.64	3.42	3.15	3.12	1.73	1.50	1.38	1.47
	With money gap	2.04	1.88	1.88	2.08	3.50	3.15	3.11	3.42	1.65	1.44	1.42	1.60

Note: Grey shading indicates models that produce lower RMSEs than the base model that excludes money.

Table 12 (continued)

Restricted recursive VECMs for price-inflation-forecast RMSE (percentage), broad money excluding M1

		Horizon				Horizon				Horizon			
		1	2	4	8	1	2	4	8	1	2	4	8
		1970Q1–1996Q4				1970Q1–1984Q4				1982Q1–1996Q4			
M3β	No money gap	2.05	1.88	1.73	1.77	3.53	3.24	2.72	2.51	2.24	1.83	1.55	1.10
	With money gap	2.06	1.89	1.90	2.19	3.35	3.06	3.00	3.50	2.13	1.75	1.52	1.45
LLβ	No money gap	2.04	1.88	1.71	1.71	3.53	3.24	2.70	2.42	2.26	1.86	1.53	1.37
	With money gap	2.05	1.88	1.87	2.08	3.34	3.06	2.93	3.30	2.17	1.80	1.55	1.54
M5	No money gap	2.01	1.80	1.57	1.54	3.43	3.10	2.53	2.22	2.19	1.70	1.33	0.84
	With money gap	2.02	1.80	1.78	2.00	2.66	2.49	2.56	3.27	2.10	1.65	1.31	1.10
		1970Q1–1998Q4				1970Q1–1984Q4				1982Q1–1998Q4			
M1	No money gap	1.98	1.93	1.84	2.01	3.62	3.44	2.89	2.53	1.67	1.55	1.47	1.29
M1_Adj	No money gap	1.97	1.89	1.82	1.97	3.62	3.44	2.89	2.53	1.65	1.49	1.40	1.20
M1PP	No money gap	2.02	1.91	1.85	1.98	3.64	3.42	3.15	3.12	1.73	1.50	1.38	1.47
	With money gap	2.04	1.88	1.88	2.08	3.50	3.15	3.11	3.42	1.65	1.44	1.42	1.60

Note: Grey shading indicates models that produce lower RMSEs than the base model that excludes money.

11 Current Forecasts Based on Broad Money

This section asks what the broad-money aggregates are now forecasting for inflation. It also takes a closer look at forecasts based on M2P_Adj and M2PP_Adj, the preferred measures of broad money.

I generated forecasts in the same manner as for the restricted recursive VECM indicators of section 8 (Table 10). The only models shown are those that exclude money gaps, because money gaps were not found to improve forecasting accuracy in section 8's assessment of the historical period. In addition, the sequence of inflation forecasts may tend to be somewhat spiky because successive forecasts involve revising the starting point of the forecast and re-estimating the coefficients of the indicator models; thus a smoothing method is used. The objective is to use a moving average of inflation forecasts that is long enough to smooth out any spikes but short enough that it does not impair broad money's ability to forecast turning points in inflation. With these objectives in mind I used a 4-quarter moving average of inflation forecasts.

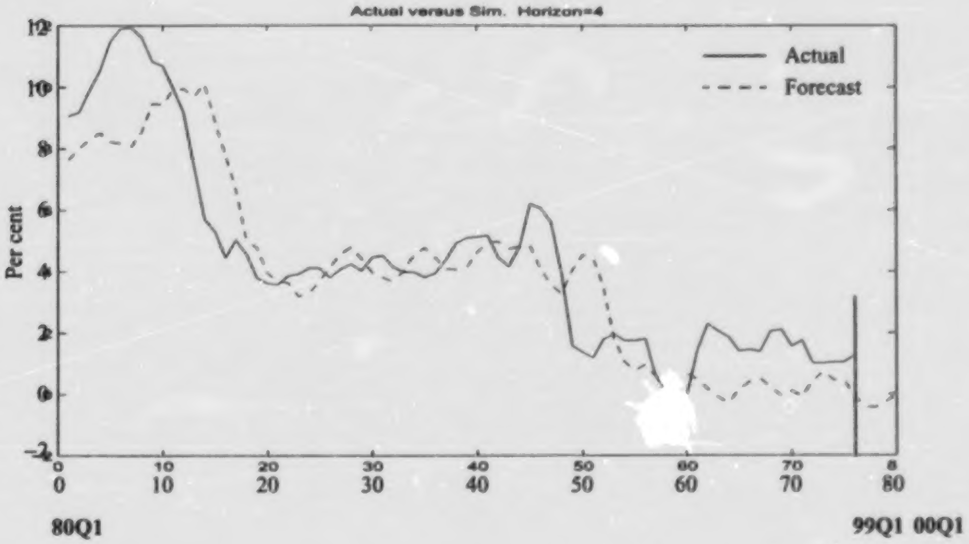
Figure 5 shows that M2P_Adj does a reasonable job of forecasting inflation over the period 1980Q1–1998Q4, but over the last five years it has under-predicted inflation. Over the forecast horizon the M2P_Adj model predicts average inflation of 0 over the next four quarters and less than 0 over the next eight quarters.

The downward bias in recent quarters may be because M2P_Adj does not fully internalize the shift out of deposits and into mutual funds that recent data reveal. M2P_Adj includes mutual funds at financial institutions, but excludes other mutual funds. Thus this aggregate may now be less reliable than an aggregate that includes all mutual funds. The same downward bias over the last five years is evident in inflation forecasts based on M2 and M2P, aggregates that include no mutual funds. It appears that the shift out of deposits and into mutual funds, even if it does not show up as instability in the long-run money-demand function, affects inflation forecasts derived from aggregates that exclude mutual funds. In fact, it is this effect that has caused the Bank in recent years to de-emphasize M2 and M2P and focus more on M2PP_Adj as a policy guide.

In Figure 6, models based on M2PP_Adj, which includes all mutual funds, also forecast reasonably well over the historical period, but unlike M2P_Adj, these models show no particular bias over the last five years. Over the forecast horizon, M2PP_Adj is forecasting average inflation of just under 2 per cent at both 4- and 8-quarter horizons.

Figure 5
M2P_Adj inflation forecasts

4-quarter horizon



8-quarter horizon

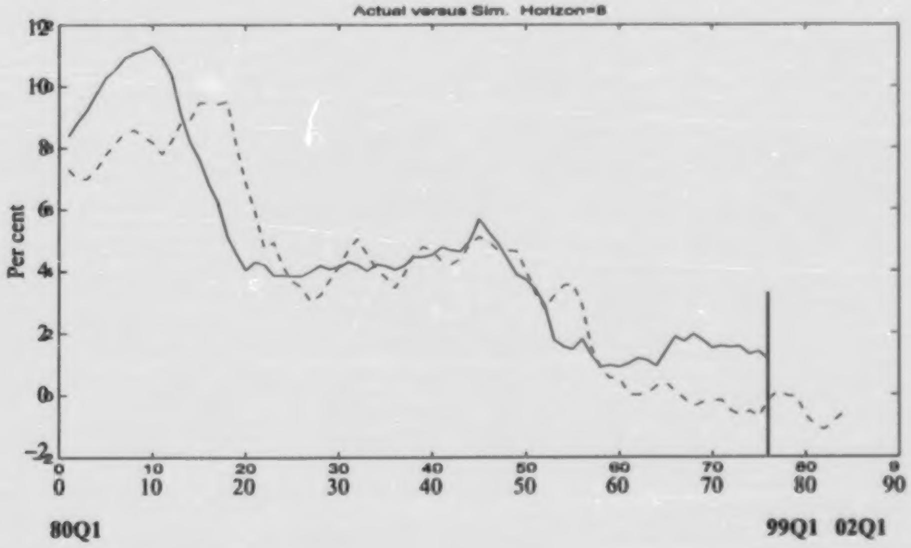
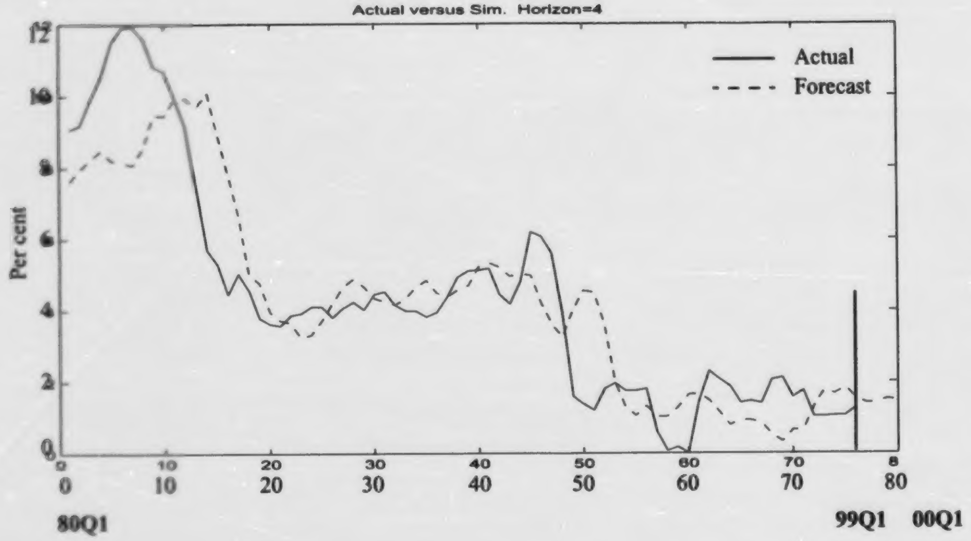
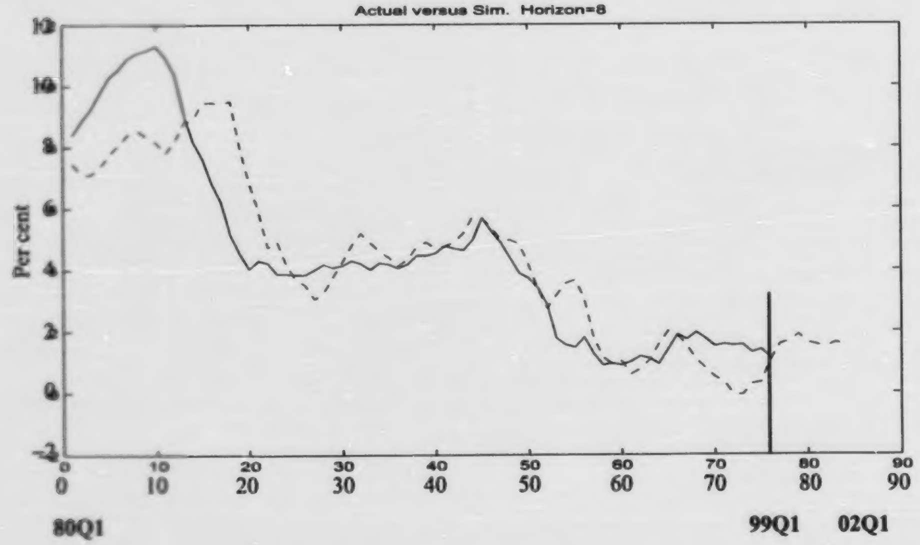


Figure 6
M2PP_Adj inflation forecasts

4-quarter horizon



8-quarter horizon



12 What Does It All Mean?

One model that has been used in the literature to explain empirical broad-money functions is the buffer-stock model. According to this characterization of the transmission mechanism, money temporarily held in excess of demand spills over to push up spending and put upward pressure on prices. Broad money is suitable as a buffer because it can be cheaply converted into a useful form in the event of a spending or income shock.

However, the results of this paper are not very encouraging to proponents of the buffer-stock hypothesis. While the results of section 6 indicate that money gaps help to explain inflation, the out-of-sample VECM results of Tables 9 and 10 show that money growth, not money gaps, accounts for much of broad money's power to explain inflation. That is, models that include money growth but exclude money gaps tend to forecast inflation as well as or better than models that include both money growth and money gaps.

Many conventional economic models could not predict money growth's ability to forecast inflation, even when output and interest rates are taken into account. This phenomenon is more in line with the standard quantity theory of money, a theory that tends to focus on the longer-run proposition that inflation is caused by past money growth but does not explain in detail the transmission mechanism nor rely on the importance of money gaps, as the buffer-stock theory emphasizes.

An additional explanation of why money growth forecasts inflation may arise through expectations. If money demand depends on current prices and on expected future prices, then higher expected inflation would generate an increase in money growth. To the extent that expectations were correct, the current increase in money growth would be validated by an increase in future inflation—that is, money growth would lead inflation. According to this motive it would be money growth rather than money gaps that would contribute to inflation forecasts, thus supporting the empirical evidence found here.

It may be that in the case of the narrow aggregates, the buffer-stock model is a valid explanation of money's role in the economy, whereas for broad money an explanation related to expectations is more suitable. Given that narrow money is held for transactions reasons while broad money's main function is as a savings vehicle, this should not be surprising.

Conclusion

In my introduction I asked whether broad money can be a useful monetary policy variable. The results of this paper suggest that it can.

The evidence of stability for the Johansen-Juselius estimates over the last 30 years suggests that one can be confident in the estimates of long-run money demand and what they imply—that a growth rate of about 6 per cent in real balances is consistent in the steady state with 2 per cent inflation. There is little evidence of instability in these relationships because of shifts in velocity or changing financial intermediation since the 1980s, as has been found in the U.S. case or for narrow-money aggregates in Canada.

The recursive VECMs suggest that broad money is a useful indicator of inflation at long horizons and thus a useful monetary policy tool. Long-horizon inflation forecasts that include broad money have lower RMSEs than do forecasts that exclude money. The usefulness of broad money in such forecasts appears to have persisted into the 1980s and 1990s.

The empirical results I have presented on the stability of long-run money demand and the usefulness of broad money for forecasting inflation hold for most of the definitions of broad money that I tested for. The results are robust and apply to more than just one or two specific cases. Nevertheless, according to the criteria used here, M2P_Adj and, especially, M2PP_Adj, which consist of M2P together with CSBs and mutual funds, are apparently the most reliable of the broad-money aggregates I considered.

How the best of the broad aggregates performs over time should be monitored. Shifts, such as the recent shift out of M2P towards mutual funds (a shift internalized within M2PP_Adj), are possible in the future. The optimal definition of broad money could evolve.

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Discussion

Alain Paquet

On the Motivation for and Relevance of Finding Monetary Aggregates' Place in Monetary Policy

A broad consensus in economics is that in the long run, core inflation is a monetary phenomenon, and money is neutral with respect to real quantities and relative prices. The focus on core inflation is to distinguish an ongoing general rise in the price level from transitory upward or downward jumps resulting from short-run sluggishness in price adjustments and from changes in major relative prices that feed into the price level.[1]

In fact, the theoretical underpinning of core or fundamental inflation as a monetary phenomenon rests solely on the equilibrium precept that all money in circulation is willingly held; i.e., there is an equilibrium between money supply and money demand:

$$\frac{M_t^S}{P_t} = \frac{M_t^D}{P_t} = L(Y_t, i_t^c, \ldots), \tag{1}$$

where M_t is the quantity of money, P_t is the price level, Y_t is real GDP, i_t^c is the nominal interest rate on a competing asset, and $L(\cdot)$ represents the demand function for real balances. From the total derivative of this equilibrium relationship we see that inflation results from the excess growth rate of money supply relative to its real demand:

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[1] As an illustration, an OPEC-induced oil-price increase that underlies an increase in the observed general price level should not trigger per se a shift towards a more restrictive anti-inflation monetary policy. Nor should it lead to an accommodative monetary policy that seeks to increase real economic activity. To the extent that a central bank cares about core inflation, what matters is to be transparent about it and to pursue a monetary policy that is consistent with the inflation target.

$$\pi_t = \Delta M_t^S - \Delta L(Y_t, i_t^c, \ldots) . \qquad (2)$$

This fundamental result does not impose any specific working of the labour or goods markets, nor that the long-run demand for money be the same as the short-run demand for money.

While the long-run view is largely accepted, there is more debate about the effects of money in the short run, with possibly a majority of economists believing that money is not neutral in the short run. Non-neutrality may arise because of a combination of nominal (or real) rigidities in prices or wages, incomplete information, and/or a limited-participation constraint interacting with the way money is injected into the economy. Consensus is still lacking on which of these dominates. Empirically, uncertainty exists about how important the transitory real effects are on economic fluctuations and how long they last. There is also the issue that these effects mostly stem from unanticipated changes in monetary policy. Ultimately the only guaranteed eventual effect is on the price level. These uncertainties underlie the view that it is not desirable to use monetary policy to attempt to stabilize real economic activity—a view that is now largely shared by economists and central bankers.

A difficult task—that the economic profession has not completed despite progress in clarifying what we still do not understand—is to link the theoretical concept of money to a satisfactory and encompassing empirical counterpart.

Lucas (1977, 232–3) pretty much summed up the issue:

> In the "long run," general price movements arise primarily from changes in the quantity of money. Moreover, cyclical movements in money are large enough to be quantitatively interesting. . . . The direct evidence on short-term correlations between money, output, and prices is much more difficult to read. . . . In general, however, the link between money and these and other variables is agreed to be subject, in Friedman's terms, to "long and variable lags."
>
> . . . *why* monetary effects work with long and variable lags. On this question little is known. It seems likely that the answer lies in the observation that a monetary expansion can occur in a variety of ways, depending on the way the money is "injected" into the system, with different price response implications depending on which way is selected. This would suggest that one should describe the monetary "state" of the

> economy as being determined by some *unobservable* monetary aggregate, loosely related to observed aggregates over short periods but closely related secularly.

While economics still struggles with identifying money's empirical counterpart in the data, by their avowed practices central banks also seem to have given up on monetary aggregates. At the very least, many of them have to a great extent de-emphasized an explicit role for monetary aggregates, so much so that, in the language of central bankers, output gaps are the pre-eminent indicators of inflationary pressures. Analyses refer more readily to aggregate demand/aggregate supply than to money. It almost seems that we have forgotten the equivalence, in a general-equilibrium sense, between excess growth of aggregate demand relative to aggregate supply resulting from excess money creation and excess money creation itself as described by equation (2).

There is another way in which money's place in monetary policy has been reduced. Most countries have chosen to focus on a very short-term interest rate (e.g., the overnight rate in Canada and the federal funds rate in the United States) as the operational target in preference to a narrow aggregate such as the monetary base.[2] This is sometimes motivated by the presumed and often documented instability in monetary aggregates, especially in an era of significant financial innovations that have changed the empirical meaning of money. Later I will discuss whether this has necessarily been warranted.

McPhail aims to make some significant progress regarding the empirical relevance of money to monetary policy on the basis of a broad econometric investigation in cointegrated systems. As she states, "The purpose of this paper is not to characterize the optimal definition of broad money from a theoretical viewpoint, but to determine from an empirical standpoint which measures of broad money appear useful" (page 56).

While I will raise some econometric issues—in the light of recent developments in modern macroeconometrics—I find that her paper makes a contribution with respect to its avowed goal. In particular a few results stand out as revealing a relevant place for broad monetary aggregates in the conduct of monetary policy. As a by-product of my comments, I will point out some paths for future research.

My discussion of McPhail's paper is organized as follows: First, I briefly present what I believe to be her main conclusions, then I organize my comments in two sets. The first set directly addresses the paper's execution and conclusions. The second set pertains to the implications of the results and issues for monetary policy and future research.

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[2] For a review and analysis of the recent conduct of monetary policy in various countries, see Bernanke et al. (1999).

The Empirical Evidence

Having presented various alternative empirical definitions of broad monetary aggregates, McPhail first aims at identifying a long-run money demand that, she argues, might encompass one or more stationary relationship(s) between the quantity of money (m), the price level (p), real GDP (y), a measure of real wealth (w), the own rate of return on the aggregate (i^o), and a competing rate of return (i^c). All variables but the rates of return are expressed in logs. The sample of quarterly data covers the 1970Q1–1998Q4 period. There are 12 definitions of broad money and 2 alternate measures of real wealth (total wealth and non-human wealth).[3]

From ADF t-ratio tests conducted at the 5 per cent significance level McPhail generally concludes that, over the whole sample, all variables are at least I(1), with most nominal and real monetary aggregates being I(1) and the price level being I(2). However, the evidence regarding the order of integration is neither invariant nor apparently consistent when considering different degrees of broadness of the monetary aggregates. For instance, while her results suggest that 6 out of 12 so-called nominal broad aggregates are I(1), M2P, M2PALLQ, M2PP, M3β, LLβ, and M5 are I(2). Also, 9 out of 12 real monetary aggregates are I(1), but *r*M3β and *r*LLβ would be I(2) and *r*M2PALLQ would be stationary.

At the next stage, McPhail estimates by full-information maximum likelihood, different VECMs for each monetary aggregate in order to investigate the existence, the dimension, and the properties of the cointegrating space that would arise from the long-run relationships between the variables of interest. As she rightly acknowledges, one has to be careful in giving a structural interpretation to the estimated vectors spanning the cointegrating space. Unless some identification restriction(s) are imposed, a wrong interpretation could be given to these vectors. Focusing on real balances—by imposing price-level homogeneity in the monetary equilibrium relationship—is akin to estimating a long-run real money demand equation between the variables of interest, provided that there is a single cointegrating vector or that the other cointegrating vector(s) can be identified, if needed.

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[3] McPhail's Table 1 provides a precise definition of the various aggregates that were considered. The sequence of mnemonics moves from the narrowest to the broadest concept of broad money: M2, M2P, M2PFIQ, M2PALLQ, M2P_Adj, M2PP_Adj, M2PP, M2PPFIQ, M2PPALLQ, M3β, LLβ, and M5.

First, if we consider the whole sample available and the most general set of variables (i.e., $[rm, y, w, i^o, i^c]'$) from which McPhail wants to obtain so-called unrestricted money-demand estimates, the evidence from both the Johansen and Juselius (1990) trace and the maximum eigenvalue statistics often suggests that there are two cointegrating vectors. Provided that one of them arises from a long-run relationship between the two rates of return, the other one might well be a money-demand equation. In some instances, however, when we consider *r*M2P, *r*M2P_Adj, and *r*M2PP_Adj, the evidence points out to only one cointegrating vector, but tests with *r*LLβ suggest that there are three cointegrating vectors. As she points out, it is disquieting that such a great variability exists across the alternative systems for each aggregate in the point estimates of the coefficients associated with real income, wealth, and interest rates.

A second set of VECMs is subsequently estimated, with McPhail considering fewer variables (namely $[rm, y, w, i^c]'$) in order to uncover a so-called restricted money demand. In this case, consistent evidence across all aggregate measures of broad money is found in support of a single cointegrating vector with the point estimates of the cointegrating vector, normalized with respect to real balances, being much similar. Furthermore, evidence—from estimates over two periods (from 1970Q1 to 1984Q4 and from 1982Q1 to 1998Q4) and the application of a Chow-type test—supports the stability of the restricted long-run money demand.

Focusing on an individual dynamic price equation and taking into account that the inflation rate may be I(0) during the later period also suggest that broad money is significant.

Finally, McPhail considers the information content of monetary aggregates in forecasting inflation. Recursive VECM indicators were used to construct 1-, 2-, 4-, and 8-period-ahead forecasts of inflation. The RMSEs of the forecasts were found to be lower when accounting for movements in broad money. More specifically, M2P_Adj and M2PP_Adj performed statistically best in forecasting inflation.

Comments on the Econometrics

While McPhail's econometric treatment is applied systematically, some issues deserve further consideration to ensure the robustness of the results.

Regarding the data measures that were employed, it would have been useful had McPhail discussed her reasons for her use of the CPI as the empirical counterpart of the price level rather than using a concept of core inflation (e.g., CPI excluding food, energy, and effects of indirect taxes).

As her empirical approach rests on evidence about the order of integration of the variables, some comments about the execution of the unit-root tests and the interpretation of their results are in order. First, it has been shown that the ADF unit-root test is not very powerful because of the need to estimate deterministic components (e.g., a constant and a linear trend). These are nuisance parameters that affect the distribution of the ADF test and make it more difficult to reject the null hypothesis of integration. Recently Elliot, Rothenberg, and Stock (1996) have developed a procedure, the Dickey-Fuller generalized least-squares (DF-GLS) unit-root test, that is much more powerful. Essentially their proposed test is constructed after the deterministic components are estimated on the basis of a quasi-difference of the original series so that the alternative hypothesis is more precisely defined. This test is becoming more widely used, and it might help in assessing evidence about the order of integration in the monetary aggregates. As it stands, McPhail's paper does not provide much detail on which specifications were retained for the deterministic regressors.

Second, the results of ADF (and DF-GLS) unit-root tests are dependent on the selection of the lag length on the first difference of the series in the empirical model that is estimated to compute the statistics. Too long a lag length will lead to a drop in the test's power, and too short a lag length will bias the test against the unit-root hypothesis. The use of Akaike's information criterion (AIC) to select this lag length has been known to be problematic. Ng and Perron (1995) found that this and other traditional information criteria tended to select models that were too parsimonious, thus leading to serious size distortions. Instead, they advocate the use of the data-dependent procedure, first suggested by Campbell and Perron (1991), according to which the lag length is selected on the basis of a recursive t-statistic procedure. More recently, Ng and Perron (1997) have also recommended, based on Monte Carlo experiments, the use of a modified AIC that takes into account the possible dependence of the estimated autoregressive parameter on the number of lags in the first difference of the series.

Third, one must be careful about the existence of negative moving-average components in the underlying data-generating processes (DGPs) of integrated time series. These are known to distort the size of usual unit-root tests (e.g., Schwert 1989 and DeJong et al. 1992) unless an appropriate method of estimation is used (e.g., Pantula and Hall 1991).

Fourth, given the indirect evidence of a change in the underlying DGP of inflation, I would have found it helpful had some empirical assessment of the unit-root hypothesis been reported for different subsamples. Also, a top-down approach to test for more than one unit root (e.g., Dickey and Pantula 1987) might well be advised and be preferable to a sequence of two separate unit roots on the level and the first difference of the series. I would also recommend that a recursive testing of the two unit roots be performed by varying the sample period in order to more systematically assess the possibility of a change in the underlying DGP of the aggregates.

Fifth, another issue pertaining to the stability of the DGP of the series is that of shifts or breaks in the mean and/or in the deterministic trend of a series. Such shifts may wrongly lead one to conclude that unit roots are present. Perron and Rodriguez (1998) have extended Elliot, Rothenberg, and Stock's DF-GLS test to account for the deterministic part of the process changing at an unknown time.

Taking these points into account may remove what might seem to be inconsistencies in results of unit-root tests of different measures of broad money.

When modelling the VECM systems, McPhail selected lag lengths on the basis of the FPE criterion. Yet no discussion is provided on the properties of the residuals of each respective equation. At the very least, tests of no serial correlation would be warranted. This is not a trivial issue to identify the dimension of a VECM, since both under- and over-parameterization of the system will distort inferences about cointegration. The former will lead to biases and inconsistencies in the estimator of a system's parameters and possibly a spurious finding of cointegration. The latter will lead to power problems and hence a tendency to find too little evidence of cointegration.

Some cautions are also warranted when inferring the dimension of the cointegrating space on the basis of the trace and maximum eigenvalue statistics, particularly with large systems in finite samples. In a sample of near or less than 100 observations, as is the case in McPhail's paper, the tabulated asymptotic critical values may be inappropriate. One solution is to correct the statistics for the numbers of estimated parameters. Reimers (1992) has proposed such an adjustment to the maximum eigenvalue statistic, and Reinsel and Ahn (1992), and Pitarakis (1995) have proposed corrections to the trace test.

McPhail mentions that Chow-type tests were performed to assess the evidence of breaks in the estimated money-demand functions, but provides few details. Her results also indicate variability in the estimates across various aggregates. I believe that, given its importance, the issue of stability would have deserved a more systematic and formal treatment and that more details would have been useful. In particular, an empirical assessment of stability of both the cointegrating rank and cointegrating space could have been conducted (as per Hansen and Johansen 1993).

To document whether broad money contributes significantly to price dynamics, individual error-correction models (ECMs) for prices were also estimated for two subsamples as well as for the whole sample. Hansen's (1992) test could have been useful to formally evaluate the stability of the ECM equations. One issue, however, pertains to the QPM measure of the output gap, which was included amongst the regressors in these equations. If this measure was obtained from a multivariate H-P filter, the estimator would be inconsistent. Furthermore, as shown by Orphanides and van Norden (1999), estimates of output gaps are typically very imprecise.

I very much like McPhail's idea of checking the information content of monetary aggregates in ECM price equations or/and in VECMs, especially in their recursive versions. The study of the money block's impact on the RMSE of inflation forecasts is particularly revealing. An interesting and useful addendum would have been the decomposition of the RMSE in terms of its bias proportion, its variance proportion, and its covariance proportion, this last representing the unsystematic forecast errors. Other dimensions of its forecasting ability could also have been considered, such as monetary aggregates' contribution to predicting the direction of change in inflation.

Another avenue would have been to test the significance of the contribution of monetary aggregates relative to that of other variables by applying Granger non-causality tests. Such tests could then be interpreted as a formal testing of the statistical significance of the information content of the various variables. However, we have to be careful about issues pertaining to the distribution of this test in the presence of unit roots and cointegrating relationships (see Toda and Phillips 1994).

Finally, the results may be interpreted as evidence that broad money does not act as a buffer stock. However, one cannot test this just on the basis of VECMs, which are reduced forms, with the dynamics being modelled jointly with the long-run relationship.

Implications of the Results and Issues for Monetary Policy and Future Research

The paper's title enticed me to expect a substantiation that broad money can guide monetary policy. This worthy goal goes beyond the paper's contribution, as the way money can be used as a guide is not addressed. Still, as McPhail argues, "If better forecasts of inflation can be obtained by including money, then a policy strategy that includes money has a higher chance of meeting the inflation targets and keeping inflation within the target bands" (pages 51–2).

Subject to some checking for robustness, McPhail's results suggest that broad money contains relevant inflation-forecasting information. It is therefore appropriate for the Bank of Canada to be explicitly concerned with the evolution of broad money in the conduct of the Bank's monetary policy, as far as it aims to pursue an inflation rate within the announced target band.

What would be useful now is to more precisely establish money's place in the conduct of monetary policy. One could conclude from McPhail's paper that broad money is arguably a relevant indicator for conducting monetary policy, broad money carrying useful information about the state of the economy that may signal future directions in inflation. For this reason alone, the Bank of Canada might want to reconsider whether it is paying enough attention to broad money, relative to other indicators (including the output gap).

Broad money could also play a more formal role as an intermediate target. If that were the case, the Bank of Canada could then seek, by acting on its operating targets, to keep broad money along a growth path consistent with the Bank's ultimate inflation objective. McPhail's evidence does not rule out that broad money could play such a role, especially since there seems to be evidence of a stable long-run demand for an appropriately defined measure of broad money. However, she does not clearly establish this role. Further research in this regard would be welcome.[4]

Another issue goes beyond the scope of McPhail's paper but, I believe, has been too readily dismissed by many central banks even though it pertains directly to money's place in the conduct of monetary policy (see McCallum 1999). Most central banks have opted to use a short-term or overnight interest rate as an operating target in place of a particular measure of the private banks' reserves or the monetary base.

If the monetary base were the operating target, a central bank would determine this aggregate's path in a way that the resulting growth path of a broad monetary aggregate would be consistent with the inflation objective for a given expected growth rate of real money demand and a given money multiplier. Expected changes in either real money demand and/or the money multiplier would lead to adjustments in the operating target.

With the overnight nominal interest rate as the operating target, a central bank must affect the path of this very short-term interest rate for long enough so that, along the yield curve, it affects the nominal interest rate that enters the real money demand function. This way, monetary policy must be conducted so that the resulting path of broad-money growth is compatible with the ultimate inflation objective. Here, too, expected changes in real money demand resulting from changes in the expected growth rate of real economic activity and in the cost of financial intermediation will require adjustments to the operating target.

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[4] Even though the Canadian experience in the late 1970s and early 1980s with M1 as an intermediate target was unsatisfactory (mainly because of the extent of financial innovations at that time), a broader monetary aggregate could play a successful role as an intermediate target.

As shown in the appendix to my paper, the success of the monetary base as an operating target would depend on the uncertainty about the money multiplier relative to the overall uncertainty about money demand and on the uncertainty about the control of the relevant nominal interest rate. A sufficient condition for the superiority of the monetary base as an operating target is that the overall uncertainty about money demand be larger than the uncertainty about the money multiplier. This result is further reinforced when acknowledging a central bank's imperfect control over the relevant nominal interest rate, an even more imperfect control in the case of a small open economy with high capital mobility.

It is not because most central banks have resolved to use the nominal interest rate as the operating target that it is automatically the best one. Clearly this is an empirical matter that deserves additional work.

To conclude, I find McPhail's paper to be a very good invitation to further research. Such work is needed to better define the place of a broad monetary aggregate either as an indicator or as an intermediate target and to better identify its relationship with operational targets. It might also be worth reinvestigating how the use of a very narrow aggregate, such as the monetary base, as the operational target could fare relative to the performance of the overnight interest rate.

Appendix
Effects of Various Sources of Uncertainty on the Choice of an Operating Target

The following model is adapted from McCallum (1989) by adding uncertainty relative to a central bank's control of the relevant short-term interest rate.

Let real money demand be represented by

$$m_t = p_t + a_0 + a_1 y_t - a_2 i_t^c + \varepsilon_t , \qquad \text{(A1)}$$

where m_t is the log of the broad-money aggregate, p_t the log of the price level, y_t the log of real GDP, i_t^c the nominal interest rate that enters the money-demand function, and ε_t is a white-noise random variable that summarizes the uncertainty about real money demand. Here, for discussion purposes, we can think of i_t^c as the 3-month nominal interest rate.

Taking the total derivative of equation (A1), we can see that, in equilibrium, inflation arises from the excess growth rate of the money supply relative to that of real money demand.

Let the supply of broad-money aggregate be represented by

$$m_t = b_0 + b_1 \; h_t + b_2 \; i_t^c + \zeta_t , \qquad \text{(A2)}$$

where h_t is the log of the monetary base and ζ_t is a white-noise random variable that summarizes the uncertainty about the money multiplier, with variance $\sigma_\zeta{}^2$.

Let us define a combined expectations-error/money-demand disturbance as

$$z_t = p_t - p_t^e + y_t - y_t^e + \varepsilon_t , \qquad \text{(A3)}$$

with variance σ_z^2.

Suppose that m_t^* is the quantity of broad money compatible with a growth rate in line with the central bank's inflation target. It can be shown that if the central bank were to choose the path of the monetary base as its operating target, the mean-squared error of inflation would be given by

$$E(m_t - m_t^*)^2 \Big|_{base} = \frac{a_2^2 \sigma_\zeta^2 + b_2^2 \sigma_z^2}{(a_2 + b_2)^2} . \qquad \text{(A4)}$$

Instead, if the central bank uses the overnight interest rate as its operating target, it would like to establish the rate's value to yield a 3-month nominal interest rate that would in turn lead to a path for broad money compatible with the inflation objective. Let an imperfect control of the 3-month nominal interest rate along the yield curve be reflected as in

$$i_t^c = \bar{i}_t^c + \eta_t \,, \tag{A5}$$

where $\bar{i}_t^c$ is the target 3-month interest rate and η_t is a white-noise random variable that summarizes the uncertainty about the control of the interest rate, with variance σ_η^2. In this case it can be shown that the mean-squared error for inflation would be given by

$$E(m_t - m_t^*)^2 \Big|_{i^c} = \sigma_z^2 + a_2^2 \sigma_\eta^2 \,. \tag{A6}$$

This model implies that a sufficient, but not necessary, condition for the monetary base to be a superior operating target relative to the nominal interest rate is that the overall uncertainty about money demand be larger or equal to the uncertainty about the money multiplier. This would be true even if there were no uncertainty about controlling the 3-month nominal interest rate. For the overnight interest rate to dominate the money base in terms of mean-squared error, the uncertainty about the money multiplier would have to be large relative to the overall uncertainty about money demand, the elasticity of money demand relative to the interest rate would have to be relatively high (i.e., a_2 be large relative to b_2), and the uncertainty about the control of the nominal interest rate would have to be relatively small.

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Discussion

Tony S. Wirjanto

In her paper Kim McPhail addresses two important questions on the relationship between money and inflation in Canada. In particular she inquires whether stable long-run demand functions exist for broad money and whether broad money helps forecast inflation at the 4- and 8-quarter horizons after controlling for output and interest rate. After a somewhat exhaustive data search she concludes affirmatively for both questions, in particular when M2P with CSBs and mutual funds are used as the definitions of broad money.

In my discussion I will focus on her search for stable long-run money-demand functions, since that is a precursor to the second question her paper poses and will be somewhat technical. But in my conclusion I will attempt to look beyond the technical aspects of her paper and put it in a proper perspective, highlighting its potential contribution to the policy arena.

Most of what I will say is motivated by the results reported for the unrestricted long-run money-demand equations, from which her specification search takes off. In total, 12 empirical definitions of broad money are used in the study, ranging from the relatively more liquid aggregate (M2) to the relatively less liquid aggregate (M5), using quarterly data from 1970Q1 to 1998Q4 for the first six definitions and from 1970Q1 to 1996Q4 for the last six definitions. The Johansen-Juselius VECM is used as an organizing tool in the specification search from an unrestricted long-run money-demand specification to restricted ones that are thought to be data congruent.

My first comment inquires whether McPhail has included a drift term in her VECMs consistently throughout the specification search and if she has not, whether there is a strong argument for excluding it. I raise this question because allowing for a drift term in the VECM may dramatically alter the results obtained from a VECM without a drift term, including the nature of its stability or instability. Also, given the size of the data set used, it seems prudent to use some scheme to correct for a finite-sample bias of the test statistics used in the specification search, in particular the trace statistic, to minimize the frequency of over-rejections of no cointegration. There are a number of schemes available in the literature, and some of them are relatively straightforward to implement and some are not.

My second comment notes that while most inferential statements she makes are admirably done in a formal way, some, in particular those assessing the stability of the VECM estimates across the different definitions of broad money, lack formalism. It would be a good idea to adopt some formal way of discriminating between these various VECMs in terms of their in-sample stability performances in the absence of any theoretical underpinnings for these definitions. However, we can afford to forego this particular exercise if we are not searching for an optimal specification of money demand.

My third comment relates to the empirical modelling of VECM in general. The popularity of the VECM in recent years has largely to do with its ability to allow researchers to duck the issue of exogeneity in the modelling process. Unfortunately, this flexibility comes at a cost of compounding the issue of identification in an unrestricted VECM with more than one cointegrating vector. Many discussions on this issue, and hence on how to move from an unrestricted specification to a restricted one, have been made over the years, largely on the theoretical front. However, many of the proposed solutions, I am afraid, are either difficult or impossible to implement with a limited data size (such as 112 observations), a large number of variables (such as 5 or more), and longer lags for each of the variables (such as 3 or more), unless we first take a stance on the issue of exogeneity. The absence of an empirically tractable solution almost certainly will hamper an effective evaluation of the structural behaviour, including researchers' efforts to establish whether any structural changes have taken place within the sample—a possibility that has become the focus of investigation in McPhail's paper.

For example, if there are 5 variables and 3 lags for each variable in the unrestricted VAR model, we need to estimate, using only 112 observations, a total of 75 parameters. But if we treat 2 of the 5 variables as being weakly exogenous, the number of parameters to be estimated in the VAR would be reduced to 30. Clearly, in the absence of extra identifying assumptions, determining the correct number of cointegrating vectors is likely to be difficult and at best unreliable. This in turn will complicate the search for a correct specification of the structural VECM. It is desirable to classify variables in the VECM into exogenous and endogenous at the initial stage of the modelling, considerably reducing the number of parameters in the system and hence improving the performance of the tests for the number of cointegrating vectors. As a next step we can impose a set of just-identifying restrictions on the cointegrating vectors and enter these vectors in the VECM unrestrictedly, so that each equation for the endogenous variable will have all the cointegrating vectors included in it. As the cointegrating vectors are tested, not only can the model's dynamics be simplified and estimated, but also the model's causality can be established by eliminating inappropriate cointegrating vectors from each equation.

This brings me to my concluding remarks. My discussion of the technical aspects of McPhail's paper should not obscure its basic message: There are stable long-run demand functions for broad-money aggregates in Canada and these aggregates have good forecasting properties. For this statement alone she should be highly commended; her paper contributes to the argument that broad-money aggregates can play a role in forming monetary policy in Canada. To be sure, by itself the fact that no evidence of in-sample instability has been uncovered in the long-run demand functions for some of the broad-money aggregates she studied is no guarantee that these aggregates will be stable ever after. Nor do we expect this to be the case as the financial market evolves over time. However, their questionable stability is not a good enough reason for excluding them from being considered as an informal intermediate target of monetary policy; in particular it is possible to observe shifts when they occur and hence make proper allowances for their effects, and it is possible to use more than one aggregate in this role.

In closing, while the issue of the stability of broad monetary aggregates is important in assessing whether they are fit for use as an informal intermediate target of the monetary policy, it certainly should not be treated as a key issue. It seems to me that the central issue in this matter is how well these aggregates can be "controlled" by the monetary authority. And this issue of "controllability" by the monetary authority needs to be further studied and clarified in the near future.

General Discussion*

David Laidler argued that the cointegrating relationships and the negative loading on the rate of interest on competing assets appeared to be consistent with a liquidity effect working through the structure of interest rates rather than an expectations effect. If it were simply a matter of expectations, he would have expected an excess of supplies of broad money and a positive increase of interest rates on competing assets. Instead, the evidence is consistent with an active-money story for broad aggregates working in a traditional textbook way. For example, an increase in money would drive down the nominal rates of return on competing aspects.

McPhail agreed that this interpretation may be possible, noting that the effects of the money gap on the interest rate are consistent across specifications and seem to be empirically important. Alain Paquet remarked that the two interpretations can be compatible. Since VECMs are reduced forms, even if interest rates are not significant, a change in interest rates may allow an interpretation consistent with Laidler's explanation.

Graeme Wells noted that money demand is unlike demand for real products. He suggested a specification whereby a VECM with adjusting nominal money balances is transformed into a model in which people adjust real money balances and inflation is a term on the right-hand side with a negative sign. This type of specification was tried in the 1970s and early 1980s and proved inconclusive, but may be worth revisiting and could possibly explain some of the inflation-forecasting results.

McPhail explained that in the approach Wells suggests, expected inflation is thought of as leading to a reduction in the level of money balances through a shift in the opportunity cost of holding money relative to competing assets. Her model contains a rate-of-return variable that captures returns on assets, such as housing, that compete with broad money and are closely tied to inflation. Therefore an increase in this rate of return would lead to a decrease in real money balances.

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* Prepared by Carol Ann Northcott.

Robert Jones observed that some of the measures of broad money include treasury bills or bonds, the stocks of which vary with fiscal positions. He wondered whether the forecasting value of broad-money aggregates might stem from the fiscal policy stance, which the model does not otherwise include as a variable. McPhail responded that this would not be a large concern empirically because the amount of government debt in the relevant measures is relatively small.

Finally, Stefan Gerlach from the Bank for International Settlements, made two suggestions to further the model. McPhail agreed that both suggestions were useful. First, in models such as this, where prices and money growth are I(2), a common parameterization is to include the real money stock and the inflation rate. Since inflation is nonstationary, it can be included in the VECM, and this would provide a direct test of whether the money gap feeds into inflation. His second suggestion was to include a time trend that might be cointegrated with the level of output. Detrended output would be a measure of the output gap, and one could then directly test if the output gap is more important than the money gap in driving inflation.

Monetary Aggregates and Monetary Policy

Apostolos Serletis and Terence E. Molik

Introduction

Recently, economists and central bankers renewed their interest in identifying monetary policy disturbances. This involves a search for a variable, or combination of variables, to appropriately measure the stance—the looseness or tightness—of monetary policy. Over the years, many variables have been used for this purpose. For example, monetarist authors of the 1960s and 1970s, such as Friedman and Schwartz (1963), and Cagan (1972), emphasized monetary aggregates such as M1 and M2 as indicators of policy. They argued that such money measures lead output and prices, and are also positively related to changes in output (at least in the short run) and to changes in the price level (at least in the long run).

However, using monetary aggregates as indicators of policy is controversial because changes in monetary aggregates can result from factors other than changes in policy, factors such as changes in money demand or bank behaviour due to economic conditions over the business cycle. This problem with monetary aggregates as indicator variables has led many economists to consider either central bank balance-sheet measures, such as the base and various reserves measures (on the grounds that movements in these variables are dominated by changes in policy), or

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market-determined interest rates, such as the overnight rate and yield-curve spreads.

Another problem with using monetary aggregates as policy indicators is that the many studies of money's influence on the economy are based on official simple-sum money measures. Under some conditions such aggregates are appropriate, but if the relative prices of the financial components that constitute the aggregates fluctuate over time (as the evidence suggests), then simple-sum aggregation will produce theoretically unsatisfactory definitions of money. The problem is incorrectly accounting for substitution effects inherent in simple-sum aggregation, and the result is a set of monetary aggregates that do not accurately measure the actual quantities of the monetary products that optimizing economic agents select (in the aggregate).

Recently, researchers have focused on the gains that can be achieved by rigorously using microeconomic- and aggregation-theoretic foundations to construct monetary aggregates. This new approach to monetary aggregation was advocated by Barnett (1980) and has led to the construction of monetary aggregates based on Diewert's (1976) class of superlative quantity index numbers—the most recent example is Anderson, Jones, and Nesmith (1997a, 1997b). The new aggregates are Barnett's monetary services indices (also known as divisia aggregates) and Rotemberg's (1991) currency-equivalent (CE) indices—see also Rotemberg, Driscoll, and Poterba (1995). These aggregates are a viable and theoretically appropriate alternative to the simple-sum aggregates that central banks and researchers still use.

One aim of our paper is to investigate the roles of simple-sum, divisia, and CE monetary aggregates in Canadian monetary policy, using quarterly data over the 1974Q1–1998Q2 period. Our investigation used Hodrick-Prescott cyclical correlations, integration and cointegration tests, and the single-equation causality approach (with the time-series properties of the data imposed in estimation and hypothesis testing), as well as the multi-equation vector autoregression (VAR) framework, which treats all variables as part of a joint process.

The paper is organized as follows. In the next section we briefly discuss the problem of the definition (aggregation) of money, and in section 2 we describe the data. In section 3 we summarize some key facts regarding the dynamic co-movements between the different money series and real GDP, using the methodology suggested by Kydland and Prescott (1990). In section 4 we investigate the univariate time-series properties of the variables and test the existence of a long-run equilibrium relationship between money, prices, and income. In section 5 we investigate the strength of the empirical relationship connecting money to income and prices using causality tests and the single-equation approach, and in section 6 we investigate the robustness of the results of the multi-equation VAR approach. The final section is the conclusion.

1 The Many Kinds of Money

The monetary aggregates that the Bank of Canada and many central banks around the world now use are based on the simple-sum method of aggregation. The essential property of this method of monetary aggregation is that it assigns all monetary components a constant and equal (unitary) weight. This index is M in

$$M = \sum_{i=1}^{n} x_i, \tag{1}$$

where x_i is one of the n monetary components of the monetary aggregate M. This summation index assumes that the relative prices of the monetary components are constant and equal over time; this implies that component monetary assets must not only be perfect substitutes, but also dollar-for-dollar perfect substitutes. The empirical evidence shows that this is quite an unrealistic assumption—see, for example, Fleissig and Serletis (1999).

Over the years, many have attempted to properly weight monetary assets linearly within the simple-sum index. With no theory, however, any weighting scheme is questionable. The work of Diewert (1976, 1978) and Barnett (1980) was important in constructing monetary aggregates consistent with existing microeconomic and aggregation theory. These monetary aggregates are based on the so-called superlative class of quantity index numbers, among the most important of which is the discrete-time divisia index:

$$\log M_t^D - \log M_{t-1}^D = \sum_{i=1}^{n} s_{it}^{*}(\log x_{it} - \log x_{i,t-1}). \tag{2}$$

Equation (2) defines the growth rate of the money aggregate as the share-weighted average of the growth rates of the component asset quantities.

$$s_{it}^{*} = \frac{1}{2}(s_{it} + s_{i,t-1})$$

is the average of the expenditure shares from the two adjacent periods, and

$$s_{it} = \pi_{it}x_{it}/\Sigma\pi_{jt}x_{jt}$$

is the expenditure share of asset *i* during period *t*. π_{it} is the user cost of asset *i*, as derived in Barnett (1978):

$$\pi_{it} = \frac{R_t - r_{it}}{1 + R_t}, \tag{3}$$

where r_{it} is the market yield of asset *i* and R_t is the yield on the benchmark asset (theoretically the highest yield available). The benchmark asset is used only to transfer wealth from one period to another. The user cost measures the opportunity cost of the monetary services provided by asset *i* for the given period—see Barnett, Fisher, and Serletis (1992) for more details on the divisia approach to monetary aggregation.

A newer alternative index number with potential application to monetary aggregation is the Rotemberg, Driscoll, and Poterba (1995) CE index:

$$CE_t = \sum_{i=1}^{n} \frac{R_t - r_{it}}{R_t} x_{it}. \tag{4}$$

This index is basically the simple-sum index with a simple weighting mechanism added. In the event that a component monetary asset, such as currency, pays no interest, this asset will be added to the stock of monetary assets with a weight of 1. The weight applied to the individual asset will decline towards 0 as its return increases toward R_t and the asset comes to behave more like the benchmark asset (a means to transfer wealth) and less like money.

The CE and divisia indices differ in much the same way as do the simple-sum and divisia indices: The CE index under most conditions functions as a stock measure (though a different stock measure from the simple-sum index), and the divisia index functions as a flow measure. Specifically, the CE index measures the stock of monetary wealth, and the divisia index measures the flow of monetary services. However, the CE and simple-sum indices can measure the flow of monetary services if a specific set of assumptions is satisfied for each. The key difference between the CE and simple-sum indices is that the CE can measure the flow of monetary services under a less restrictive set of assumptions than the perfect and dollar-for-dollar substitutes assumption required by the simple-sum index—see Rotemberg (1991) and Barnett (1991) for more details on divisia and CE measures.

In this paper we use Canadian simple-sum, divisia, and CE monetary aggregates to investigate the relationship between money, prices, and income. The data are quarterly over the 1974Q1–1998Q2 period and are described in the following section.

2 Data

We begin with the list of monetary assets that the Bank of Canada now uses to construct five popular monetary aggregates—M1, M1+, M1++, M2, and M3. We disregard the other two monetary aggregates, M2+ and M2++, because some of the interest rate series used in these aggregates are unavailable. As shown in Table 1, M1, M1+, M1++, M2, and M3 are constructed by means of a recursive form of accounting that starts with M1 and adds blocks of items to M1 until the broadest of these aggregates, M3, is constructed.

Table 1
Bank of Canada monetary aggregates/components

Monetary aggregate	Component	CANSIM series number
	Currency outside banks	B2001
	Personal chequing accounts	B486
M1	Current accounts	B487
	Personal chequable savings deposits	B452
M1+	Non-personal chequable notice deposits	B472
	Personal non-chequable savings deposits	B453
M1++	Non-personal non-chequable notice deposits	B473
M2	Personal fixed-term savings deposits	B454
	Non-personal term deposits	B475
M3	Foreign currency deposits	B482

As we noted previously, the monetary aggregates the Bank now uses are simple-sum indices; a unitary weight is assigned to each monetary asset. In contrast, to build divisia and CE monetary aggregates we must first calculate monetary asset user costs, as defined by equation (3). To do so, we set the user cost of currency equal to 0, and to calculate user costs for demand deposits (CANSIM series B486 and B487), we use the implicit rate of return, as in Klein (1974) and Startz (1979), based on the formula

$$r_D = (1 - \kappa) r_A,$$

where r_A is the interest rate on an alternative asset and κ is an estimate of the maximum required reserve ratio. Here r_A is taken to be the interest rate on 3- to 5-year Government of Canada bonds (CANSIM B14010), and κ is constructed from both the primary and secondary reserve ratios against demand deposits over the sample period.

The interest rate on B452 is taken to be the rate on personal chequable savings deposits (CANSIM B14035) from 1974M1 to 1982M9 and the interest rate on daily-interest chequing accounts (DICA) in excess of $5,000 (DICA 5K+) from 1982M10 to 1998M6. For the interest rate on B453 we use the rate on personal non-chequable savings deposits (CANSIM B14019) from 1974M1 to 1986M12, the rate on daily-interest savings accounts (DISA) in excess of $25,000 (DISA 25K+) from 1987M1 to 1988M1, and the average of DISA 25K+ and DISA 75K+ from 1988M2 to 1998M6. Finally, we use the prime rate (CANSIM B14020) as a proxy for the interest rate on B475, the euro/US$ deposit rate (CANSIM B54415) for the interest rate on B482, the 5-year term deposit rate (CANSIM B14045) for the interest rate on B454, and the rate on 90-day personal fixed-term deposits (CANSIM B14043) for the interest rate on both B472 and B473. The 5-year term deposit rate was yield-curve adjusted to remove the premium that exists for an asset with a typically long term to maturity.

We use seasonally adjusted data and a reasonable proxy for the benchmark rate of interest (see Molik [1999] for details regarding these issues) to construct simple-sum, divisia, and CE monetary aggregates at each of the M1, M2, M3, M1+, and M1++ levels of aggregation. Figures 1 to 5 show graphical representations of these monetary aggregates. As the figures indicate, the fluctuations of the money series are different at different levels of aggregation and also across aggregation methods, reflecting the fact that monetary aggregation issues are complicated—something to be kept in mind when interpreting the results later on.

3 Some Basic Business Cycle Facts

For a description of the stylized facts we follow the current practice of detrending the data with the Hodrick-Prescott (H-P) filter—see Prescott (1986). For the logarithm of a time series X_t, for $t = 1, 2, \ldots, T$, the detrending procedure defines the trend or growth component, denoted τ_t, for $t = 1, 2, \ldots, T$, as the solution to the following minimization problem:

$$\min_{\tau_t} \quad \sum_{t=1}^{T} (X_t - \tau_t)^2 + \mu \sum_{t=2}^{T-1} [(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2, \tag{5}$$

Figure 1
Sum M1, divisia M1, and CE M1 money measures

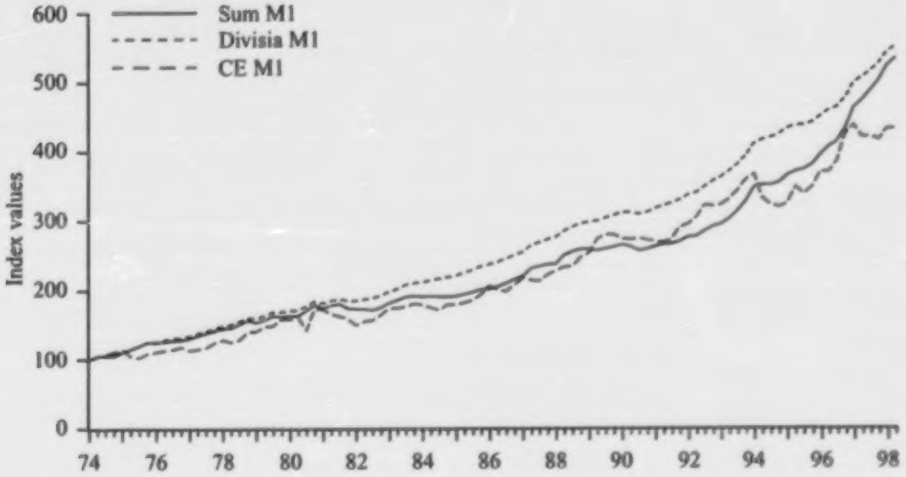


Figure 2
Sum M2, divisia M2, and CE M2 money measures

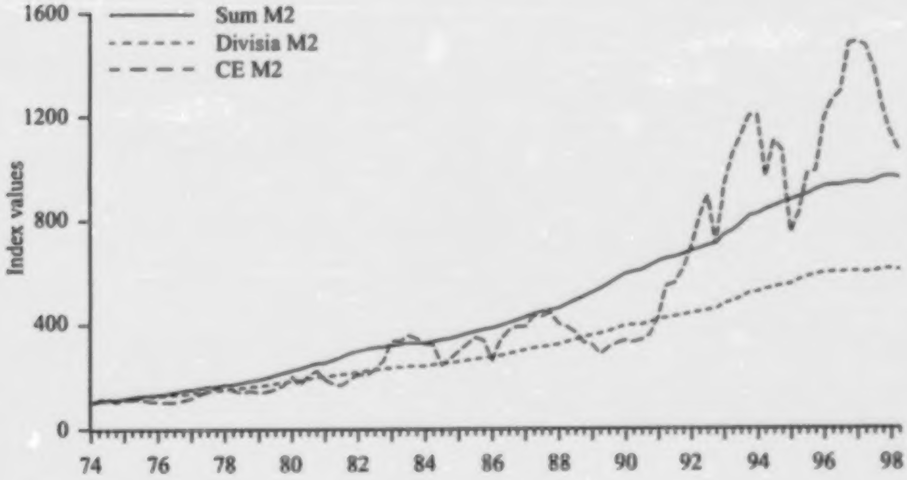


Figure 3
Sum M3, divisia M3, and CE M3 money measures

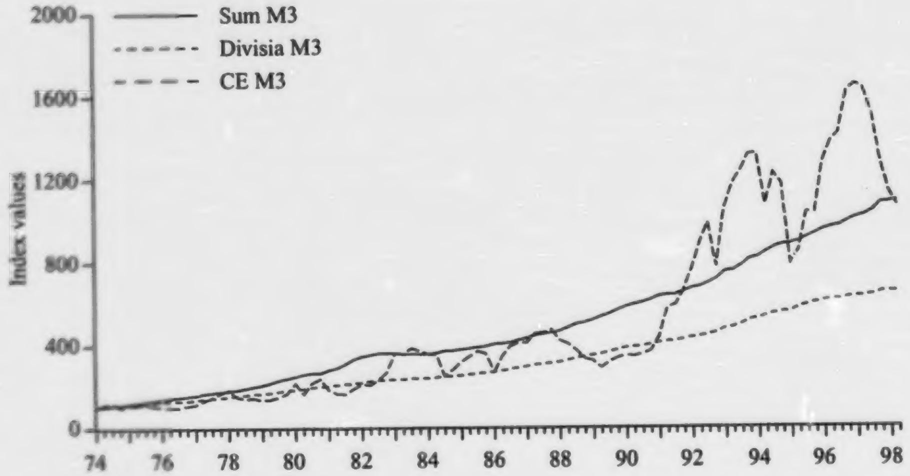


Figure 4
Sum M1+, divisia M1+, and CE M1+ money measures

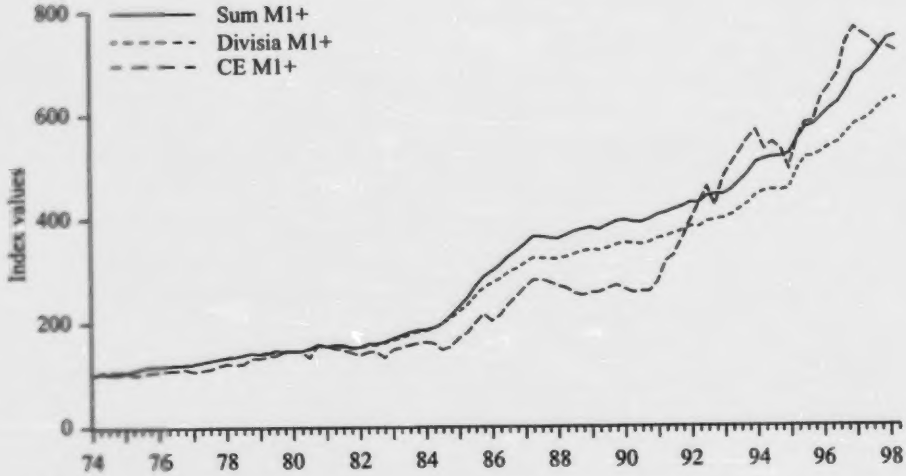
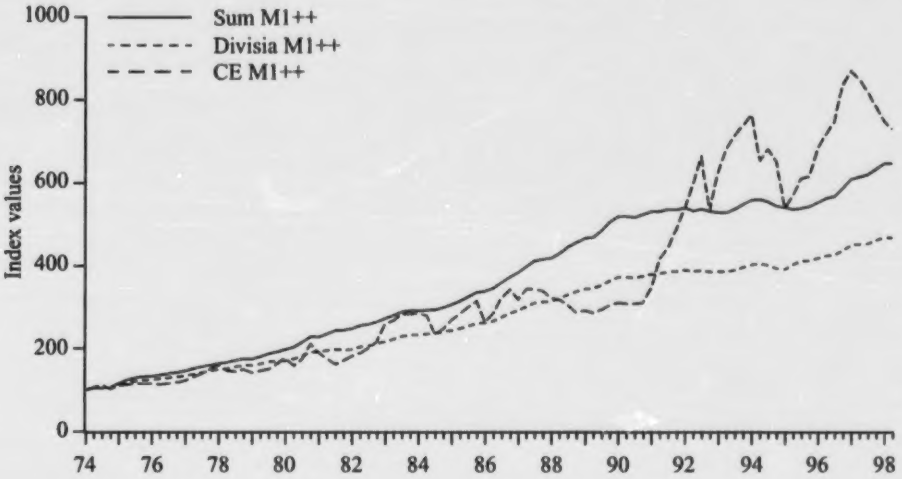


Figure 5
Sum M1++, divisia M1++, and CE M1++ money measures



so X_t divisia minus τ_t is the H-P–filtered series. The larger μ is, the smoother the trend path, and when $\mu = \infty$, a linear trend results. In our computations we set $\mu = 1,600$, as recommended by Kydland and Prescott (1990).

We measure the degree of co-movement of a money series with the cycle by the magnitude of the correlation coefficient $\rho(j), j \in \{0, \pm 1, \pm 2, \ldots\}$. The contemporaneous correlation coefficient—$\rho(0)$—gives information on the degree of contemporaneous co-movement between the series and the pertinent cyclical variable. In particular, if $\rho(0)$ is positive, zero, or negative, we say that the series is procyclical, acyclical, or countercyclical, respectively. In fact, for data samples of our size, authors such as Fiorito and Kollintzas (1994) have suggested that for $0.5 \leq |\rho(0)| \leq 1$, $0.2 \leq |\rho(0)| < 0.5$, and $0 \leq |\rho(0)| < 0.2$, we say that the series is strongly contemporaneously correlated, weakly contemporaneously correlated, or contemporaneously uncorrelated with the cycle. Also, $\rho(j), j \in \{\pm 1, \pm 2, \ldots\}$—the cross-correlation coefficient—gives information on the phase-shift of the series relative to the cycle. If $|\rho(j)|$ is maximum for a positive, zero, or negative j, we say that the series is leading the cycle by j periods, is synchronous, or is lagging the cycle by j periods.

In Table 2 we report contemporaneous correlations as well as cross correlations between the cyclical component of money and the cyclical component of real output at lags and leads of 1, 2, 3, 4, 6, and 9 quarters. Clearly, sum M1, divisia M1, sum M1+, and divisia M1+ are procyclical

Table 2

Hodrick-Prescott cyclical correlations of money measures with real GDP

$\rho(M_t, Y_{t+j}), j = -9, -6, -4, -3, -2, -1, 0, 1, 2, 3, 4, 6, 9$

Series	$j = -9$	$j = -6$	$j = -4$	$j = -3$	$j = -2$	$j = -1$	$j = 0$	$j = 1$	$j = 2$	$j = 3$	$j = 4$	$j = 6$	$j = 9$
Sum M1	0.108	0.031	0.016	0.063	0.180	0.345	0.489	0.637	0.687	0.582	0.428	0.115	–0.236
Divisia M1	–0.120	–0.118	–0.060	0.019	0.177	0.371	0.536	0.704	0.764	0.669	0.524	0.217	–0.135
CE M1	0.154	0.133	0.025	–0.006	0.029	0.098	0.193	0.264	0.252	0.202	0.180	–0.010	–0.214
Sum M2	0.213	0.402	0.366	0.267	0.137	–0.023	–0.186	–0.304	–0.388	–0.447	–0.480	–0.479	–0.423
Divisia M2	0.054	0.381	0.364	0.247	0.139	0.053	–0.005	–0.007	–0.016	–0.063	–0.127	–0.271	–0.375
CE M2	0.033	–0.193	–0.486	–0.569	–0.622	–0.601	–0.454	0.243	–0.047	0.124	0.260	0.391	0.304
Sum M3	0.257	0.287	0.277	0.197	0.081	–0.066	–0.251	–0.398	–0.490	–0.530	–0.524	–0.390	–0.311
Divisia M3	0.104	0.404	0.390	0.266	0.156	0.062	–0.014	–0.029	–0.042	–0.085	–0.143	–0.272	–0.391
CE M3	0.028	–0.200	–0.493	–0.573	–0.623	–0.599	–0.449	–0.235	–0.042	0.123	0.259	0.385	0.289
Sum M1+	–0.134	0.234	0.282	0.275	0.297	0.350	0.414	0.492	0.522	0.484	0.425	0.324	0.296
Divisia M1+	–0.206	0.173	0.264	0.271	0.303	0.364	0.433	0.512	0.545	0.511	0.461	0.371	0.324
CE M1+	0.027	–0.048	–0.185	–0.260	–0.172	–0.083	0.057	0.169	0.240	0.287	0.315	0.320	0.293
Sum M1++	0.578	0.424	0.159	0.038	–0.031	–0.060	–0.055	–0.010	–0.007	–0.088	–0.197	–0.373	0.346
Divisia M1++	0.545	0.413	0.142	0.006	–0.042	–0.012	0.061	0.179	0.228	0.153	0.028	–0.208	–0.280
CE M1++	0.003	–0.273	–0.556	–0.640	–0.675	–0.606	–0.414	–0.185	0.002	0.148	0.257	0.342	0.328

Note: Sample period quarterly data, 1974Q1–1998Q2.

(divisia M1 is more so) and lead the cycle—recall that a monetary aggregate leads the cycle if its cross correlations with future real output are larger (in absolute value) than the contemporaneous correlation. Sum M3, CE M2, CE M3, and CE M1++ are countercyclical, and the remaining aggregates are acyclical. These results appear to support a monetary effect on real output only in the case of the sum M1, divisia M1, sum M1+, and divisia M1+ aggregates and also illustrate some differences across simple-sum, divisia, and CE monetary aggregates.

4 The Data's Integration and Cointegration Properties

4.1 Integration tests

In the single-equation approach, estimation and hypothesis testing critically depend on the variables' univariate time-series properties. Therefore, in what follows we test for unit roots using three different testing procedures to deal with anomalies that arise when the data are not very informative about whether or not there is a unit root.

In the first two columns of Table 3 we report *p* values for the augmented Dickey-Fuller (ADF) test (see Dickey and Fuller [1981]) and the nonparametric, $Z(\tau_{\hat{\alpha}})$ test of Phillips (1987) and Phillips and Perron (1988). These *p* values (calculated using time-series processor 4.5) are based on the response surface estimates given by MacKinnon (1994). For the ADF test we selected the optimal lag length according to the Akaike information criterion (AIC) plus 2—see Pantula, Gonzalez-Farias, and Fuller (1994) for details on the advantages of this rule for choosing the number of augmenting lags. The $Z(\tau_{\hat{\alpha}})$ test was done with the same Dickey-Fuller regression variables, using no augmenting lags. Based on the *p* values for the ADF and $Z(\tau_{\hat{\alpha}})$ test statistics reported in panel A of Table 3, the null hypothesis of a unit root in levels cannot generally be rejected at conventional significance levels. This is consistent with the Nelson and Plosser (1982) argument that most macroeconomic time series have stochastic trends.

In the unit root-tests that we have discussed so far, the unit root is the null hypothesis to be tested, and the way in which classical hypothesis testing is carried out ensures that the null hypothesis is accepted unless there is strong evidence against it. In fact, Kwiatkowski et al. (1992) argue that such unit-root tests fail to reject a unit root because they have low power against relevant alternatives, and they propose tests, called KPSS tests, of the hypothesis of stationarity against the alternative of a unit root. They argue that such tests should complement unit-root tests and that by testing both the unit-root hypothesis and the stationarity hypothesis, one can distinguish series that appear to be stationary, series that appear to be

Table 3
Unit-root and stationarity test results in the variables

	A. Log levels				B. First differences of log levels			
	p values		KPSS *t*-statistics		*p* values		KPSS *t*-statistics	
Series	ADF	$Z(t_{\hat{\alpha}})$	$\hat{\eta}_\mu$	$\hat{\eta}_\tau$	ADF	$Z(t_{\hat{\alpha}})$	$\hat{\eta}_\mu$	$\hat{\eta}_\mu$
Sum M1	0.949	0.958	1.227*	0.267*	0.045	0	0.287	0.205*
Divisia M1	0.13	0.265	1.289*	0.308*	0.029	0	0.192	0.159*
CE M1	0.029	0.014	1.284*	0.292*	0	0	0.034	0.025
Sum M2	0.98	0.993	1.289*	0.314*	0.06	0	1.558*	0.102
Divisia M2	0.976	0.99	1.290*	0.315*	0.009	0	1.049*	0.139
CE M2	0.061	0.111	1.093*	0.253*	0	0	0	0.041
Sum M3	0.367	0.838	1.280*	0.311*	0.032	0	1.057*	0.176*
Divisia M3	0.829	0.613	1.276*	0.322*	0.14	0	0.621*	0.175*
CE M3	0.052	0.091	1.079*	0.244*	0	0	0.048	0.041
Sum M1+	0.091	0.663	1.275*	0.246*	0.404	0	0.147	0.128
Divisia M1+	0.044	0.601	1.280*	0.249*	0.252	0	0.122	0.116
CE M1+	0.378	0.631	1.144*	0.301*	0.001	0	0.115	0.052
Sum M1++	0.98	0.976	1.324*	0.13	0.011	0	1.210*	0.061
Divisia M1++	0.949	0.977	1.330*	0.125	0	0	1.017*	0.049
CE M1++	0.072	0.097	1.182*	0.233*	0	0	0.053	0.039
Deflator	0.906	0.985	1.298*	0.308*	0	0	2.784*	0.097
Nominal GDP	0.868	0.981	1.329*	0.102	0.007	0	1.789*	0.215*
Real GDP	0.152	0.588	1.319*	0.06	0.01	0	1.685*	0.118

Notes: Sample period quarterly data, 1974Q1–1998Q2. Numbers in the ADF and $Z(t_{\hat{\alpha}})$ columns are tail areas of unit-root tests. An asterisk next to a KPSS *t*-statistic indicates significance at the 5 per cent level. The 5 per cent critical values for the KPSS $\hat{\eta}_\mu$ and $\hat{\eta}_\tau$ *t*-statistics (given in Kwiatkowski et al. [1992]) are 0.463 and 0.146 respectively.

integrated, and series that are not very informative about whether or not they are stationary or have a unit root.

KPSS tests for level and trend stationarity are presented in the KPSS columns in panel A of Table 3. As can be seen, the *t*-statistic $\hat{\eta}_\mu$ that tests the null hypothesis of level stationarity is large relative to the 5 per cent critical value of 0.463 given in Kwiatkowski et al. (1992). As well, the statistic $\hat{\eta}_\tau$ that tests the null hypothesis of trend stationarity exceeds the 5 per cent critical value of 0.146, also given in Kwiatkowski et al. (1992); the exceptions are sum M1++, divisia M1++, nominal GDP, and real GDP. Combining the results of the stationarity hypothesis tests with the results of unit-root hypothesis tests, we conclude that all the series have at least one unit root.

To test the null hypothesis of a second unit root, we test both the null hypothesis of a second unit root—using the ADF and $Z(t_{\hat{\alpha}})$ tests—and the null hypotheses of level and trend stationarity in the first differences of the series. The results are shown in panel B of Table 3. Clearly, some of the series (such as sum M1, divisia M1, sum M3, and to a larger extent, divisia M3) are not very informative about whether or not they are stationary in their first differences, since both the null hypothesis of a second unit root and the null hypothesis of trend stationarity are rejected. However, combining the results of the tests of the unit-root hypothesis and of the level and trend stationarity hypotheses, we conclude that these variables have one unit root, keeping in mind that some of the variables are not very informative about their time-series properties.

4.2 Cointegration tests

As mentioned earlier, causality tests critically depend on the data's integration and cointegration properties. In particular, if the variables are integrated but not cointegrated, ordinary least squares (OLS) yield misleading results. In fact, Phillips (1987) formally proves that without cointegration, a regression involving integrated variables is spurious. In this case the only valid relationship that can exist between the variables is in terms of their first differences. If, however, the variables are integrated and cointegrated, then the short-run dynamics can be described by an error-correction model in which the short-run dynamics of the variables in the system are influenced by the deviation from the long-run equilibrium.

To present empirical evidence on this issue, we test the null hypothesis of no cointegration (against the alternative of cointegration) between each money measure and the price level, nominal income, and real income, using the Engle and Granger (1987) two-step procedure. This involves regressing one variable against another to obtain the OLS regression residuals $\hat{e}$. A test of the null hypothesis of no cointegration (against the alternative of cointegration) is then based on testing for a unit root in the regression residuals using the ADF test and critical values, which correctly take into account the number of variables in the cointegration regression.

In Table 4 we show asymptotic p values, computed using the coefficient estimates in MacKinnon (1994), of the bivariate cointegration tests (in log levels). The entries are p values for testing the null hypothesis of no cointegration. The cointegration tests are first done with one series as the dependent variable in the cointegration regression and then with the other series as the dependent variable—we should be wary of a result indicating cointegration using one series as the dependent variable but indicating no

Table 4
Marginal significance levels of Engle-Granger cointegration tests between money and prices, nominal GDP, and real GDP

	Cointegration tests between money and the GDP deflator: Dependent variable:		Cointegration tests between money and nominal GDP: Dependent variable:		Cointegration tests between money and real GDP: Dependent variable:	
Monetary aggregate	m_t	p_t	m_t	$(py)_t$	m_t	y_t
Sum M1	0.457	0.289	0.985	0.297	0.993	0.266
Divisia M1	0.15	0.092	0.989	0.299	0.994	0.251
CE M1	0.021	0.373	0.741	0.363	0.742	0.2
Sum M2	0.148	0.355	0.585	0.285	0.732	0.253
Divisia M2	0.143	0.425	0.574	0.283	0.729	0.244
CE M2	0.829	0.989	0.76	0.272	0.949	0.477
Sum M3	0.114	0.105	0.915	0.2	0.984	0.254
Divisia M3	0.034	0.12	0.647	0.243	0.774	0.242
CE M3	0.851	0.993	0.729	0.304	0.944	0.492
Sum M1+	0.16	0.562	0.932	0.449	0.909	0.149
Divisia M1+	0.141	0.559	0.877	0.433	0.929	0.153
CE M1+	0.282	0.641	0.866	0.269	0.953	0.243
Sum M1++	0.664	0.983	0.456	0.143	0.617	0.32
Divisia M1++	0.527	0.977	0.474	0.19	0.615	0.34
CE M1++	0.644	0.982	0.664	0.324	0.733	0.595

Notes: Sample period quarterly data, 1974Q1–1998Q2. All tests use a constant and trend variable. Asymptotic p values are computed using the coefficients in MacKinnon (1994). The number of augmenting lags is determined using the AIC+2 rule.

cointegration when the other series is used as the dependent variable. The tests use constant as well as trend variables, and the number of augmenting lags is chosen using the AIC+2 rule mentioned earlier.

The results suggest that the null hypothesis of no cointegration between each monetary aggregate, the price level, nominal output, and real output cannot be rejected at the 5 per cent level. These results provide guidelines as to how Granger causality tests should be performed. In fact, because of the strong evidence that the series are nonstationary and do not cointegrate, in the next section we use the single-equation approach and test for Granger causality using I(0) variables; that is, the first differences of the variables.

5 Granger Causality Tests

In this section we investigate whether monetary aggregates provide information about recent or current economic conditions that could be useful in conducting monetary policy. In doing so, we take an "information variable" approach and test for Granger causality, using the single-equation framework in which money is treated as predetermined and the integration and cointegration properties of the data are imposed in estimation.

To test for causality, in keeping with Granger (1969) it must be assumed that the relevant information is entirely contained in the present and past values of the variables. An obvious specification is

$$\Delta z_t = \alpha_0 + \sum_{j=1}^{r} \alpha_j \Delta z_{t-j} + \sum_{j=1}^{s} \beta_j \Delta m_{t-j} + u_t, \tag{6}$$

where Δz_t is the inflation rate, the growth rate of nominal output, or the growth rate of real output, and Δm_t is the growth rate of a given money measure. To test if m_t causes z_t in the Granger (1969) sense, equation (6) is first estimated by OLS, and the unrestricted sum of squared residuals (SSR_u) is obtained. Then, by running another regression equation under the restriction that all β_js are zero, the restricted sum of squared residuals (SSR_r) is obtained. If u_t is white noise, then the statistic computed as the ratio of $(\mathrm{SSR}_r - \mathrm{SSR}_u)/s$ to $\mathrm{SSR}_u/(T-r-s-1)$ has an asymptotic F distribution with numerator degrees of freedom s and denominator degrees of freedom $(T-r-s-1)$, where T is the number of observations and 1 is subtracted out to account for the constant term in equation (6).

Before we could perform Granger causality tests we had to deal with the lengths of lags r and s in equation (6). In the literature, r and s are frequently chosen to have the same value, and lag lengths of 4, 6, or 8 are used most often with quarterly data. However, such arbitrary lag specifications can produce misleading results because they may imply misspecification of the order of the autoregressive process. For example, if r or s (or both) is too large, the estimates will be unbiased but inefficient. If r or s (or both) is too small, the estimates will be biased but have smaller variances.

Here we used the data to determine the "optimum" lag structure. In particular, the optimal r and s was determined using the AIC. We considered values from 1 to 12 for each of r and s in equation (6). By running 144 regressions for each bivariate relationship we chose the one that produced the smallest value for the AIC. From these optimal specifications we present, in Table 5, p values for Granger causality F tests in the quarterly data over the 1974Q1 to 1998Q2 period.

Table 5
Tail areas of tests of Granger causality from money to prices, nominal income, and real income

	Money to prices		Money to nominal income		Money to real income	
Money measure	**AIC lags**	***p* value**	**AIC lags**	***p* value**	**AIC lags**	***p* value**
Sum M1	(9,1)	0.45	(1,4)	0.046	(1,2)	0.063
Divisia M1	(9,1)	0.537	(1,4)	0.036	(1,2)	0.048
CE M1	(9,1)	0.681	(1,1)	0.951	(1,1)	0.415
Sum M2	(5,1)	0.342	(1,5)	0.254	(1,1)	0.686
Divisia M2	(9,1)	0.587	(1,2)	0.286	(1,1)	0.798
CE M2	(9,1)	0.682	(1,1)	0.726	(1,1)	0.603
Sum M3	(5,5)	0.265	(1,1)	0.999	(1,7)	0.199
Divisia M3	(9,3)	0.488	(1,2)	0.35	(1,1)	0.946
CE M3	(9,1)	0.692	(1,1)	0.653	(1,1)	0.551
Sum M1+	(5,5)	0.224	(1,3)	0.139	(1,2)	0.122
Divisia M1+	(9,1)	0.945	(1,3)	0.234	(1,2)	0.126
CE M1+	(9,1)	0.999	(1,1)	0.999	(1,1)	0.708
Sum M1++	(9,1)	0.675	(1,5)	0.081	(1,4)	0.222
Divisia M1++	(9,1)	0.807	(1,5)	0.074	(11,8)	0.012
CE M1++	(9,1)	0.654	(1,1)	0.604	(1,1)	0.461

Notes: Sample period quarterly data, 1974Q1–1998Q2. Numbers in parentheses indicate the optimal lag specification, based on the AIC. Low *p* values imply strong marginal predictive power.

We find that the hypothesis that money does not "Granger cause" the price level cannot be rejected with each of the monetary aggregates. The hypothesis that money does not cause nominal income is rejected only with the sum M1, divisia M1, sum M1++, and divisia M1++ aggregates—note that divisia M1 produces a smaller test tail area than do the other aggregates. Finally, the hypothesis that money does not cause real output is rejected only with the sum M1, divisia M1, and divisia M1++ aggregates. In conclusion, none of the monetary aggregates appears to be a good leading indicator of inflation, divisia M1 is apparently the best leading indicator of nominal income, and divisia M1++ is apparently the best leading indicator of real income.

To investigate the robustness of these results under alternative specifications, we applied the statistical approach Stock and Watson (1989) used in their study of U.S. money-output causality. This involves including a short-term interest rate in equation (6) and deciding whether removing the deterministic trend from the growth rate of each money measure sharpens the relationship between money and real output. We therefore considered the following specification with I(0) variables:

$$\Delta y_t = \alpha_0 + \sum_{j=1}^{r} \alpha_j \Delta y_{t-j} + \sum_{j=1}^{s} \beta_j \Delta m_{t-j} + \sum_{j=1}^{q} \gamma_j \Delta R_{t-j}, \\ + \phi t + u_t, \tag{7}$$

where R is the 90-day treasury bill rate and t is a linear trend. The inclusion of t is equivalent to detrending each variable individually, and thus the causality tests focus on the marginal predictive power of detrended money growth. As in Stock and Watson (1989), we tested for causality with no time trend and with a linear time trend. Again, we used the AIC with values from 1 to 12 for each of r, s, and q in equation (7), and by running 1,728 regressions for each trivariate relationship we chose the one that minimizes the AIC. The results, based on these optimal lag specifications, appear in Table 6.

The results show that including the interest rate does not change the predictive power of money over the 1974Q1–1998Q2 sample period. Moreover, including the linear time trend does not seem to significantly change statistical inference regarding the strength of the empirical relationship between money and real output.

6 Evidence from VARs

The Granger causality results just reported evaluate the proposition that both anticipated and unanticipated money movements influence real output. Moreover, the single-equation approach (of the previous section) can be interpreted as a VAR in which a specific subset of coefficients is restricted to equal 0. We investigated the robustness of the Granger causality results by using the multi-equation VAR framework, in which the variables were treated as jointly determined. In doing so, we also evaluated the effects of unanticipated shocks by tracing out the implied impulse-response functions.

We considered Sims's (1992) classic 4-variable VAR, consisting of the interest rate (R), the logged money supply (M), the logged price level (P), and logged real GDP (Y), in that order. That is, we assumed that the interest rate is determined before the money supply (an interest-rate-targeting operating procedure). We used quarterly data over the 1974Q1–1998Q2 period, set the lag length equal to six quarters, and ignored low-frequency variables such as linear trends. The interesting comparison is running the different monetary aggregates through otherwise identical models.

Table 6
Tail areas of tests of Stock and Watson (1989) causality from money and interest rates to real output

	No trend			Linear trend		
Money measure	**AIC lags**	**Money**	***R***	**AIC lags**	**Money**	***R***
Sum M1	(1,2,1)	0.059	0.507	(1,2,1)	0.053	0.455
Divisia M1	(1,2,1)	0.043	0.389	(1,2,1)	0.044	0.389
CE M1	(3,1,3)	0.452	0.154	(1,2,12)	0.431	0.074
Sum M2	(1,5,3)	0.676	0.465	(1,5,3)	0.364	0.407
Divisia M2	(3,2,7)	0.221	0.071	(3,2,7)	0.3	0.062
CE M2	(3,1,3)	0.673	0.15	(3,1,3)	0.723	0.132
Sum M3	(1,7,3)	0.287	0.54	(8,8,12)	0.096	0.024
Divisia M3	(3,2,3)	0.439	0.113	(1,2,7)	0.325	0.136
CE M3	(3,1,3)	0.677	0.156	(3,1,3)	0.734	0.137
Sum M1+	(1,10,7)	0.108	0.158	(3,10,7)	0.064	0.045
Divisia M1+	(1,1,3)	0.289	0.483	(1,2,7)	0.181	0.33
CE M1+	(3,1,3)	0.981	0.159	(1,2,12)	0.868	0.079
Sum M1++	(1,5,7)	0.103	0.194	(1,5,7)	0.101	0.114
Divisia M1++	(1,2,12)	0.054	0.007	(1,2,12)	0.067	0.01
CE M1++	(3,1,3)	0.559	0.176	(3,1,3)	0.616	0.155

Notes: Sample period quarterly data, 1974Q1–1998Q2. Numbers in parentheses indicate the optimal lag specification, based on the AIC. Low p values imply strong marginal predictive power.

The marginal significance levels for Granger causality F-tests and 5-year forecast-error-variance decompositions for each of the 15 money measures appear in Table 7. The p values are for the null hypothesis of no causality from the variable in the column heading to the variable in the row heading. Clearly, the hypothesis of no causality from money to real output can be rejected at conventional significance levels only with the sum M1, divisia M1, sum M1++, and divisia M1++ monetary aggregates. The hypothesis, however, of no causality from the interest rate to real output can in general be rejected, irrespective of how money is defined.[1]

The forecast-error-variance decompositions in panel B of Table 7 show percentages of the 5-year forecast-error variance of a variable explained by its own shocks versus shocks to other variables. The forecast-error-variance decompositions show that innovations in money explain a

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[1] Because the VARs are run in levels and the coefficients have non-standard unit-root distributions, the marginal significance levels reported in the table are not exact. Nevertheless, they are still useful for relative comparisons between specifications employing the different money measures.

Table 7
Unrestricted VAR results for {*R*, *M*, *P*, *Y*} model

	A. Marginal significance levels for exclusion of lags				B. Forecast-error-variance decompositions (20-quarter horizon)			
Equation	***R***	***M***	***P***	***Y***	***R***	***M***	***P***	***Y***
Sum M1								
R	0	0.135	0.243	0.116	27.596	25.267	34.341	12.795
Sum M1	0.012	0	0.128	0.854	60.324	9.044	15.678	14.952
P	0.556	0.589	0	0.894	0.605	24.667	71.219	3.508
Y	0.116	0.093	0.038	0	34.221	23.864	19.962	21.951
Divisia M1								
R	0	0.052	0.095	0.099	26.861	17.009	44.446	11.682
Divisia M1	0.014	0	0.216	0.656	47.278	7.619	27.167	17.934
P	0.825	0.801	0	0.982	0.838	12.026	84.635	2.498
Y	0.067	0.06	0.037	0	32.16	22.59	25.862	19.385
CE M1								
R	0	0.186	0.029	0.109	29.494	9.133	54.267	7.105
CE M1	0.249	0.001	0.142	0.158	30.286	38.483	26.693	4.536
P	0.475	0.359	0	0.935	1.775	2.919	95.166	0.138
Y	0.015	0.249	0.032	0	55.557	5.667	26.316	12.457
Sum M2								
R	0	0.431	0.09	0.12	36.945	4.03	50.942	8.082
Sum M2	0.066	0	0.416	0.686	12.456	71.099	9.631	6.812
P	0.757	0.754	0	0.999	2.953	4.857	90.846	1.342
Y	0.01	0.11	0.015	0	53.436	10.465	24.767	11.33
Divisia M2								
R	0	0.278	0.081	0.107	37.393	7.275	48.151	7.18
Divisia M2	0.337	0	0.345	0.524	12.957	75.533	0.873	10.634
P	0.093	0.761	0	0.991	3.903	3.804	92.036	0.254
Y	0.014	0.312	0.319	0	50.835	12.032	24.797	12.333
CE M2								
R	0.001	0.358	0.064	0.054	30.311	2.109	58.344	9.235
CE M2	0.305	0	0.736	0.07	19.748	38.329	26.12	15.801
P	0.284	0.73	0	0.999	6.217	5.825	87.227	0.729
Y	0.025	0.468	0.038	0	49.387	1.92	32.525	16.167
Sum M3								
R	0	0.171	0.05	0.083	27.06	7.245	58.739	6.954
Sum M3	0.176	0	0.887	0.598	12.065	72.826	14.402	0.705
P	0.634	0.573	0	0.999	3.978	0.242	95.61	0.169
Y	0.016	0.227	0.031	0	47.324	7.983	32.027	12.664
Divisia M3								
R	0	0.426	0.084	0.104	37.379	2.389	51.709	8.521
Divisia M3	0.431	0	0.496	0.234	17.075	68.958	3.175	10.79
P	0.719	0.789	0	0.999	2.833	5.375	91.451	0.339
Y	0.015	0.376	0.03	0	52.826	7.807	26.272	13.093

(continued)

Table 7 (continued)
Unrestricted VAR results for {*R, M, P, Y*} model

Equation	A. Marginal significance levels for exclusion of lags				B. Forecast-error-variance decompositions (20-quarter horizon)			
	R	*M*	*P*	*Y*	*R*	*M*	*P*	*Y*
					CE M3			
R	0	0.246	0.068	0.042	31.601	1.929	57.384	9.083
CE M3	0.265	0	0.791	0.08	22.081	36.251	23.828	17.837
P	0.319	0.828	0	0.999	6.277	5.573	87.599	0.548
Y	0.027	0.506	0.041	0	49.605	2.133	32.31	15.95
					Sum M1+			
R	0	0.231	0.054	0.092	34.576	8.423	44.146	12.853
Sum M1+	0.172	0	0.186	0.552	41.364	27.343	26.659	4.632
P	0.748	0.303	0	0.885	2.822	7.804	86.564	2.808
Y	0.054	0.215	0.043	0	53.827	3.392	23.079	19.7
					Divisia M1+			
R	0	0.167	0.059	0.075	29.783	15.635	41.173	13.408
Divisia M1+	0.29	0	0.214	0.892	31.191	36.504	27.279	5.024
P	0.67	0.397	0	0.896	1.849	11.83	84.166	2.153
Y	0.086	0.48	0.053	0	45.326	9.691	22.472	22.508
					CE M1+			
R	0.001	0.327	0.025	0.151	22.97	7.207	63.129	6.692
CE M1+	0.187	0	0.231	0.15	2.606	33.661	58.499	5.232
P	0.488	0.352	0	0.999	1.584	0.767	96.471	1.176
Y	0.01	0.178	0.016	0	45.462	3.834	37.056	13.646
					Sum M1++			
R	0	0.146	0.057	0.067	27.113	30.332	37.208	5.346
Sum M1++	0.119	0	0.892	0.416	6.092	56.184	32.153	5.569
P	0.482	0.989	0	0.971	5.989	6.85	87.005	0.154
Y	0.01	0.057	0.025	0	26.766	52.598	9.699	10.935
					Divisia M1++			
R	0	0.087	0.427	0.066	26.361	25.791	43.201	4.645
Divisia M1++	0.317	0	0.596	0.332	24.201	57.208	12.779	5.812
P	0.544	0.988	0	0.955	5.024	3.103	91.639	0.232
Y	0.012	0.062	0.041	0	31.3	47.068	11.98	9.65
					CE M1++			
R	0	0.141	0.052	0.056	25.418	4.743	61.722	8.115
CE M1++	0.129	0	0.997	0.078	17.534	40.388	30.045	12.032
P	0.421	0.922	0	0.999	2.751	1.098	94.124	2.025
Y	0.021	0.441	0.035	0	46.327	5.717	32.682	15.273

Notes: Sample period quarterly data, 1974Q1–1998Q2. The models have been estimated with six lags. Low *p* values imply strong marginal predictive power.

very small percentage of the variance of real output except in the case of sum M1++ and divisia M1++. In fact, in the sum M1++ VAR, sum M1++ explains 52.6 per cent of the variance of real output, whereas in the divisia M1++ VAR, divisia M1++ explains 47 per cent of the variance of output. On the other hand, changes in the interest rate explain a very high percentage of the variance of output except in the case of the sum M1++ and divisia M1++ VARs. Hence, on the basis of significance levels and the variance-decomposition metric, sum M1++ and divisia M1++ perform better than the interest rate.

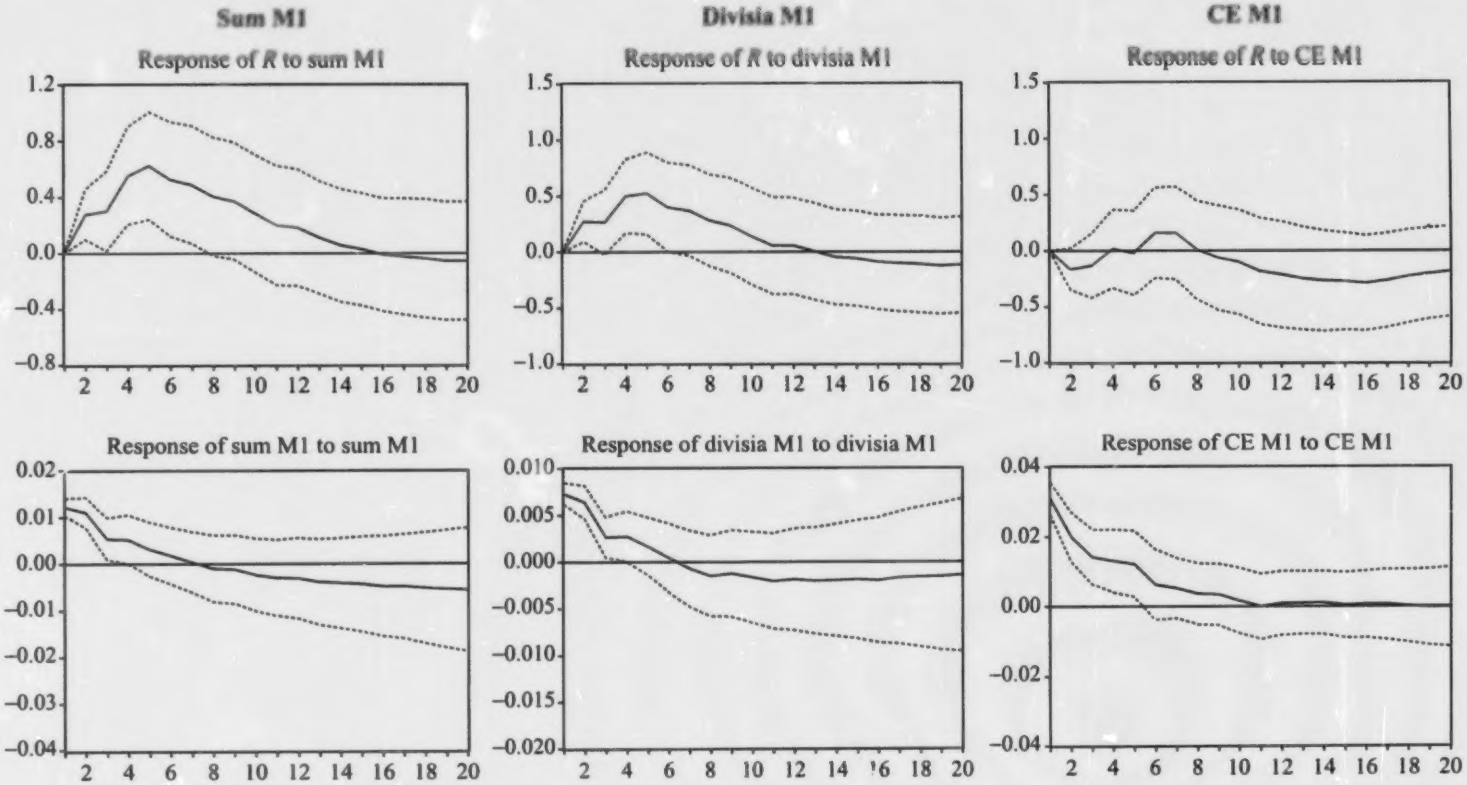
Solid lines in Figures 6 through 10 show the impulse-response functions over five years of each of the four variables (R, M, P, and Y) to each of the 15 measures of money. The dashed lines denote +2 and –2 standard deviation bands. The qualitative responses pictured in Figures 6 through 10 differ substantially across the simple-sum, divisia, and CE aggregation procedures, as well as across the M1, M2, M3, M1+, and M1++ aggregation levels. In Figure 6, for example, a major difference is that the responses of P and Y to shocks in sum M1 and divisia M1 are consistent with a priori expectations about the effects of monetary policy on output and the price level, but their responses to a shock in CE M1 are persistently negative. Also, changes in sum M1 and divisia M1 produce a liquidity puzzle, whereas changes in CE M1 produce negative effects on the interest rate at short horizons.

It is generally difficult, based on impulse-response functions, to identify a monetary aggregate that produces results consistent with common expectations about the qualitative effects of monetary policy. Of course, there have been many attempts to unravel the price and liquidity puzzles presented by VAR studies. For example, Eichenbaum's (1992) solution to the U.S. price puzzle is to use a non-borrowed-reserves VAR, while Sims's (1992) solution to the same puzzle is to extend his federal funds VAR by including a measure of commodity prices as a proxy for the central bank's information about inflation. In general, as more variables are introduced and the VAR specification is refined, monetary VARs produce results that capture reasonable monetary dynamics—see, for example, Christiano, Eichenbaum, and Evans (1996), Strongin (1995), and Bernanke and Mihov (1998). Resolving the liquidity and price puzzles we identified is well beyond the scope of this paper; see Koustas and Serletis (2000) for work in that direction.

Conclusion

We have looked at data consisting of the traditional simple-sum monetary aggregates and recently constructed divisia and CE monetary aggregates to

Figure 6
Impulse responses, {*R*, M1, *P*, *Y*} models



(continued)

Figure 6 (continued)
Impulse responses, {*R*, M1, *P*, *Y*} models

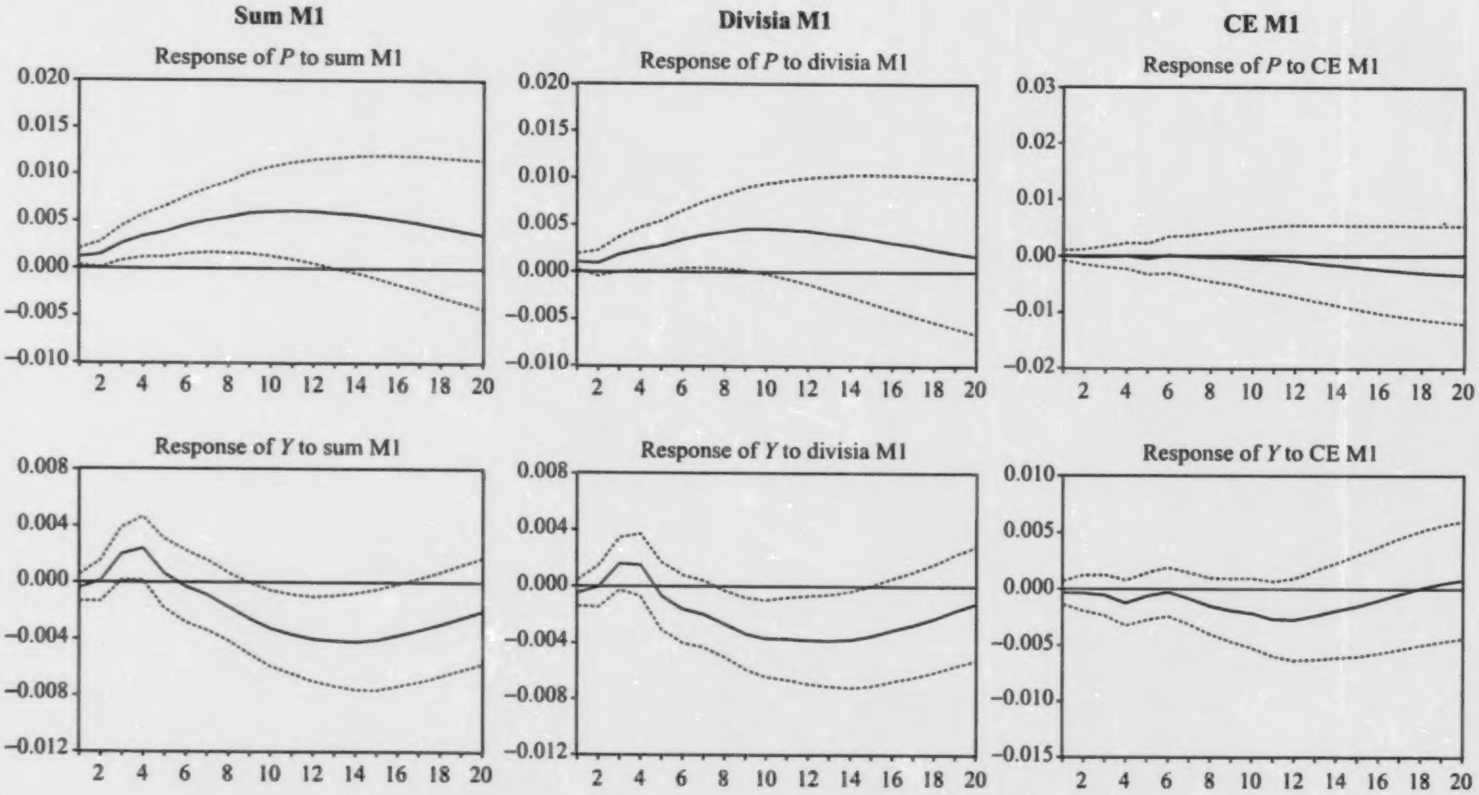
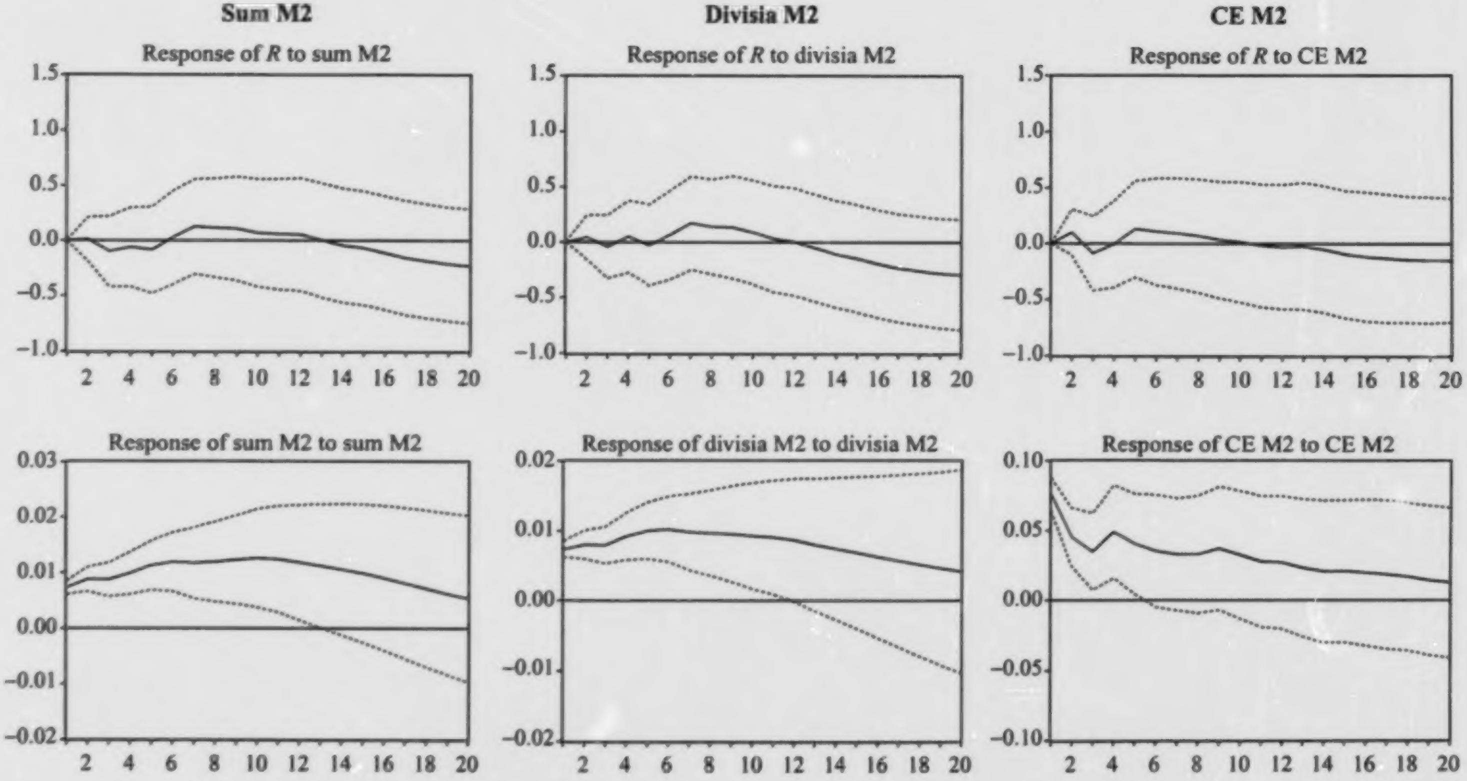


Figure 7
Impulse responses, {R, M2, P, Y} models



Sum M2

Response of *R* to sum M2

Response of sum M2 to sum M2

Divisia M2

Response of *R* to divisia M2

Response of divisia M2 to divisia M2

CE M2

Response of *R* to CE M2

Response of CE M2 to CE M2

(continued)

Figure 7 (continued)
Impulse responses, {*R*, M2, *P*, *Y*} models

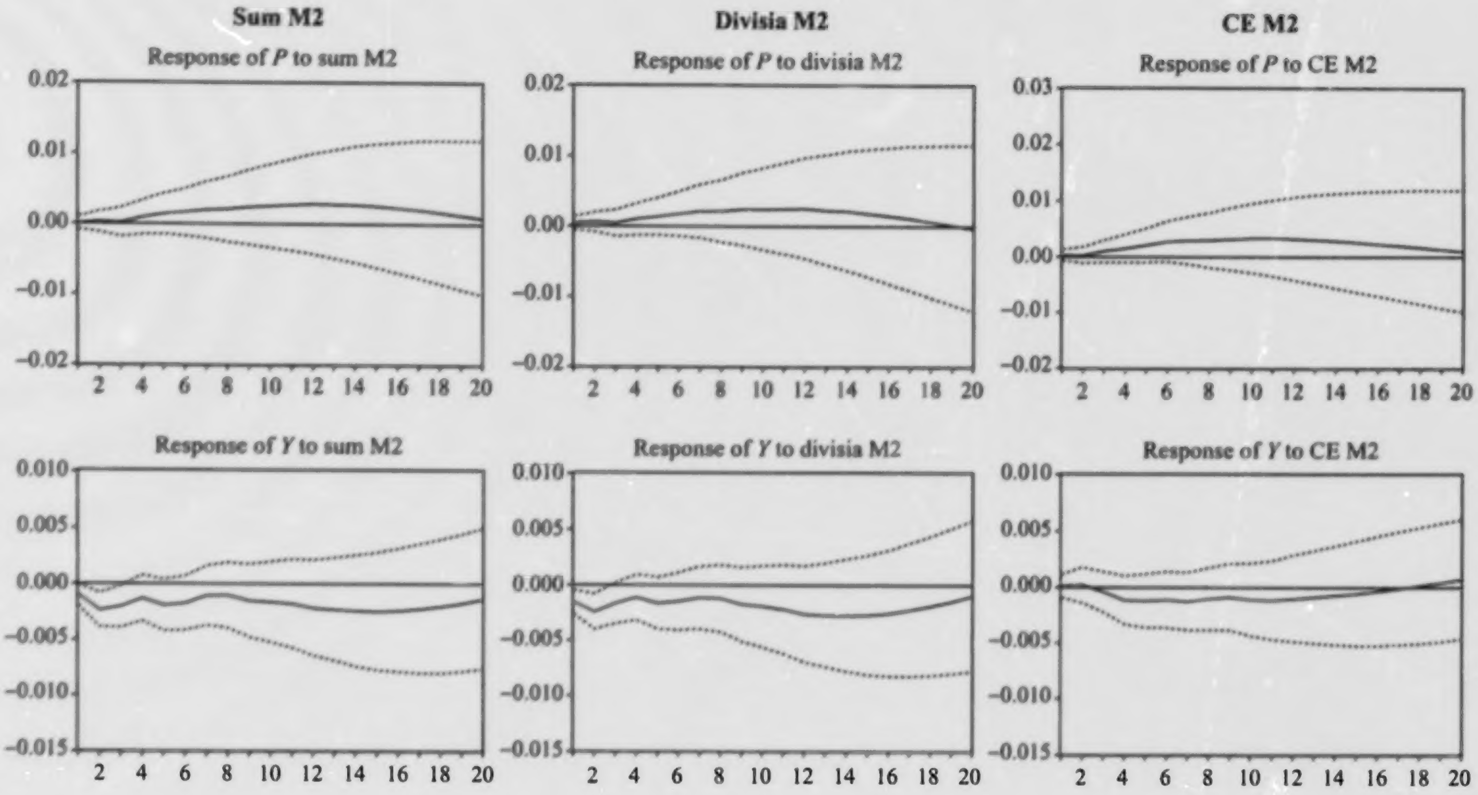
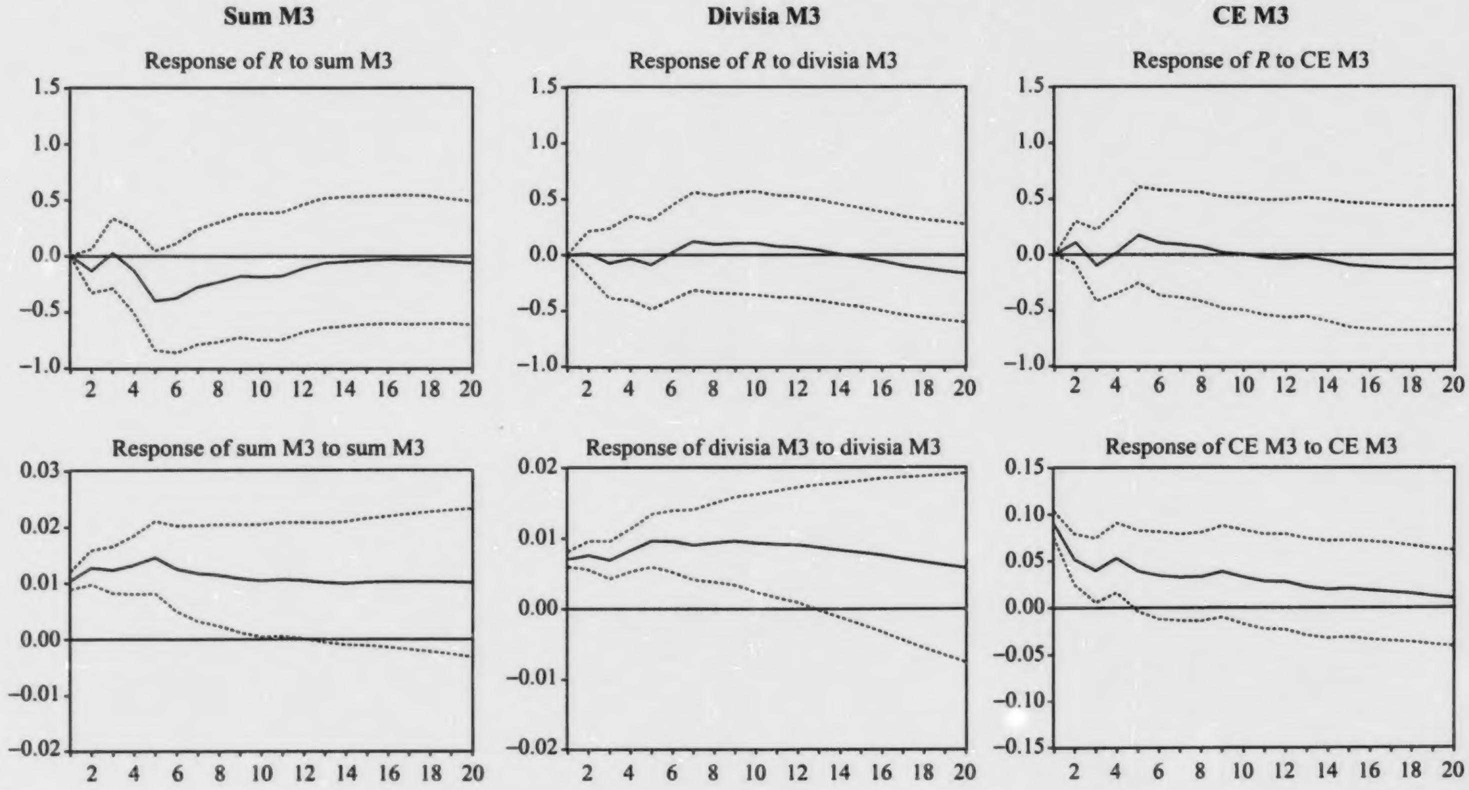


Figure 8
Impulse responses, {*R*, M3, *P*, *Y*} models



(continued)

Figure 8 (continued)
Impulse responses, {R, M3, P, Y} models

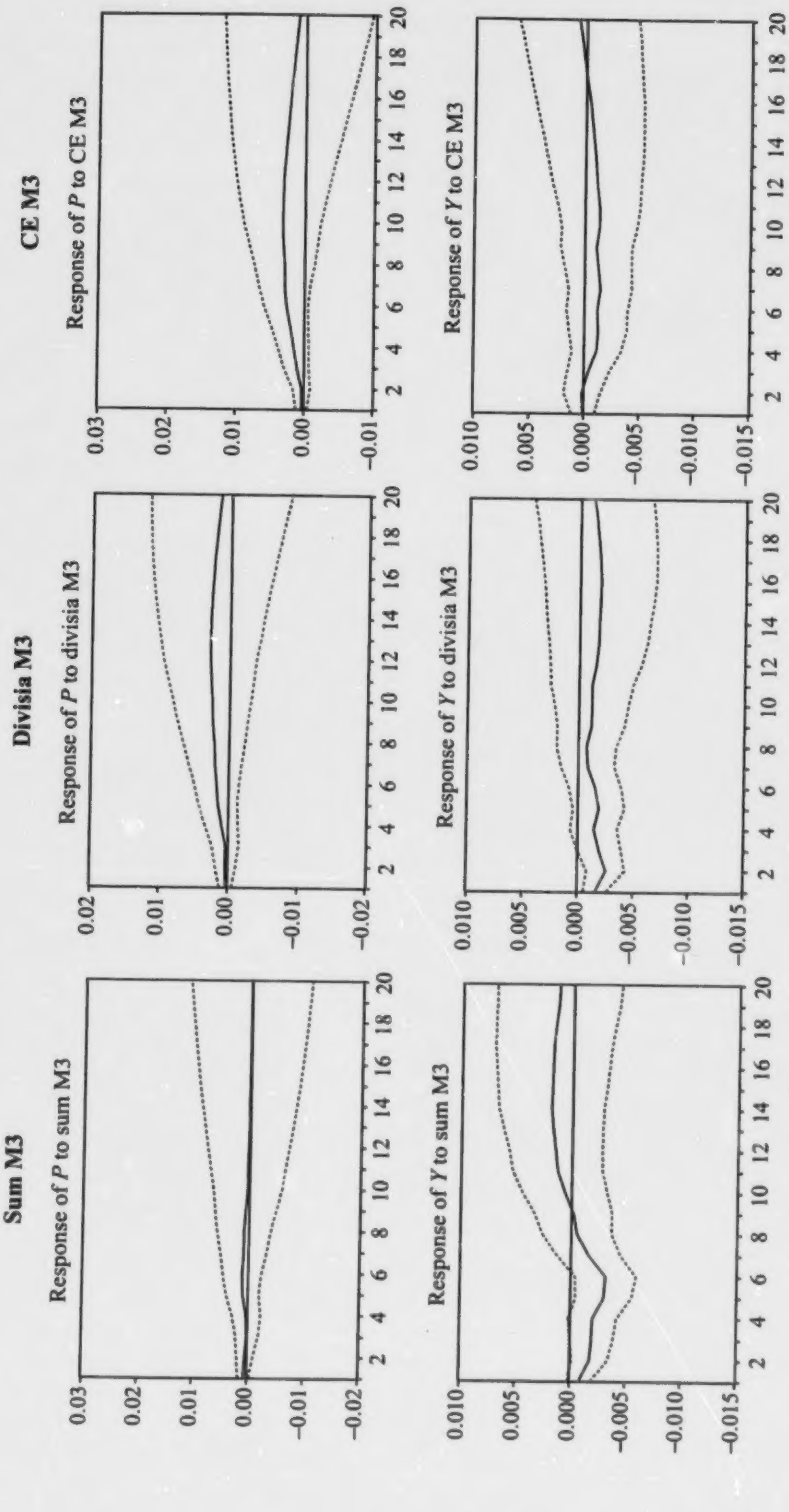
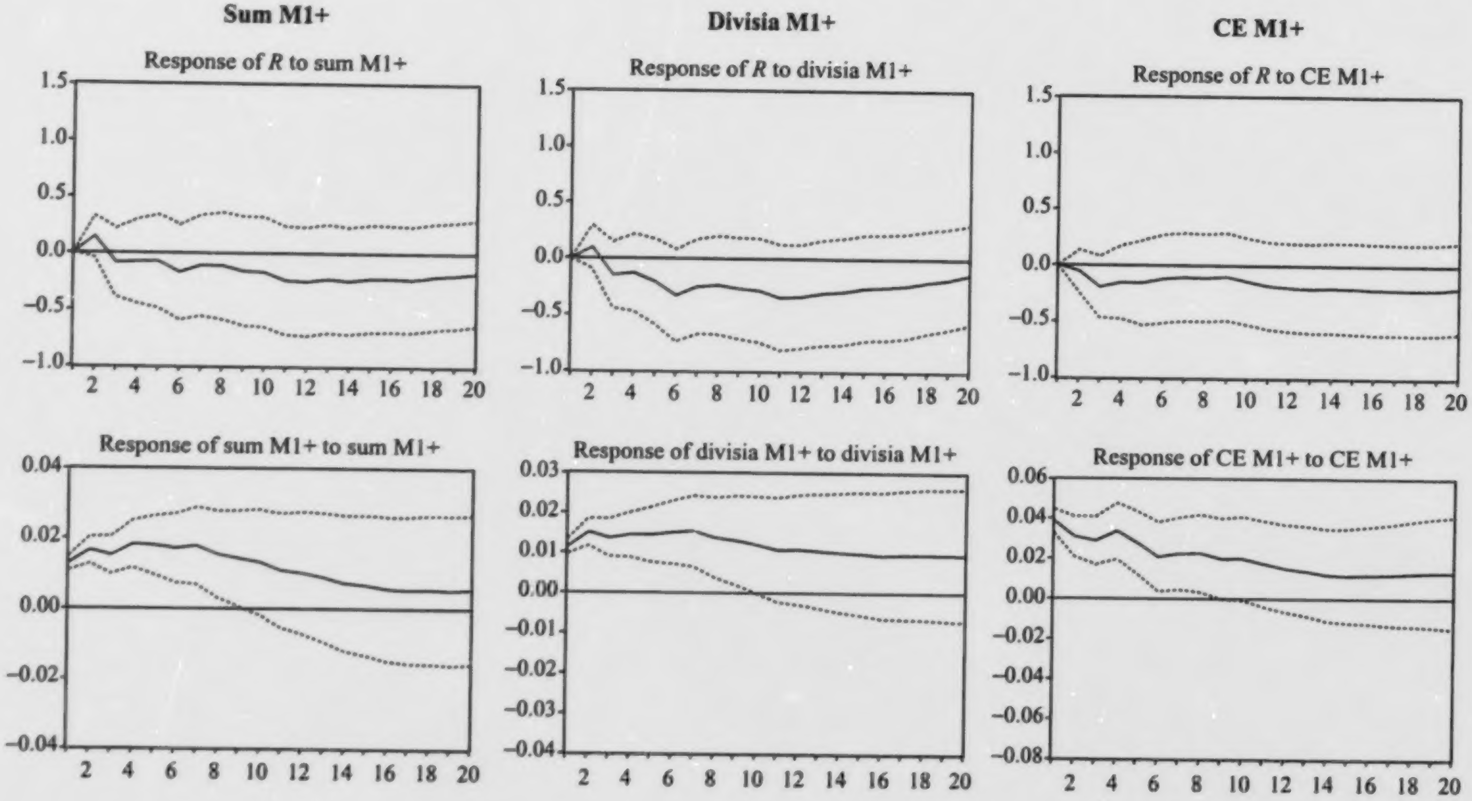


Figure 9
Impulse responses, {R, M1+, P, Y} models



(continued)

Figure 9 (continued)

Impulse responses, {*R*, M1+, *P*, *Y*} models

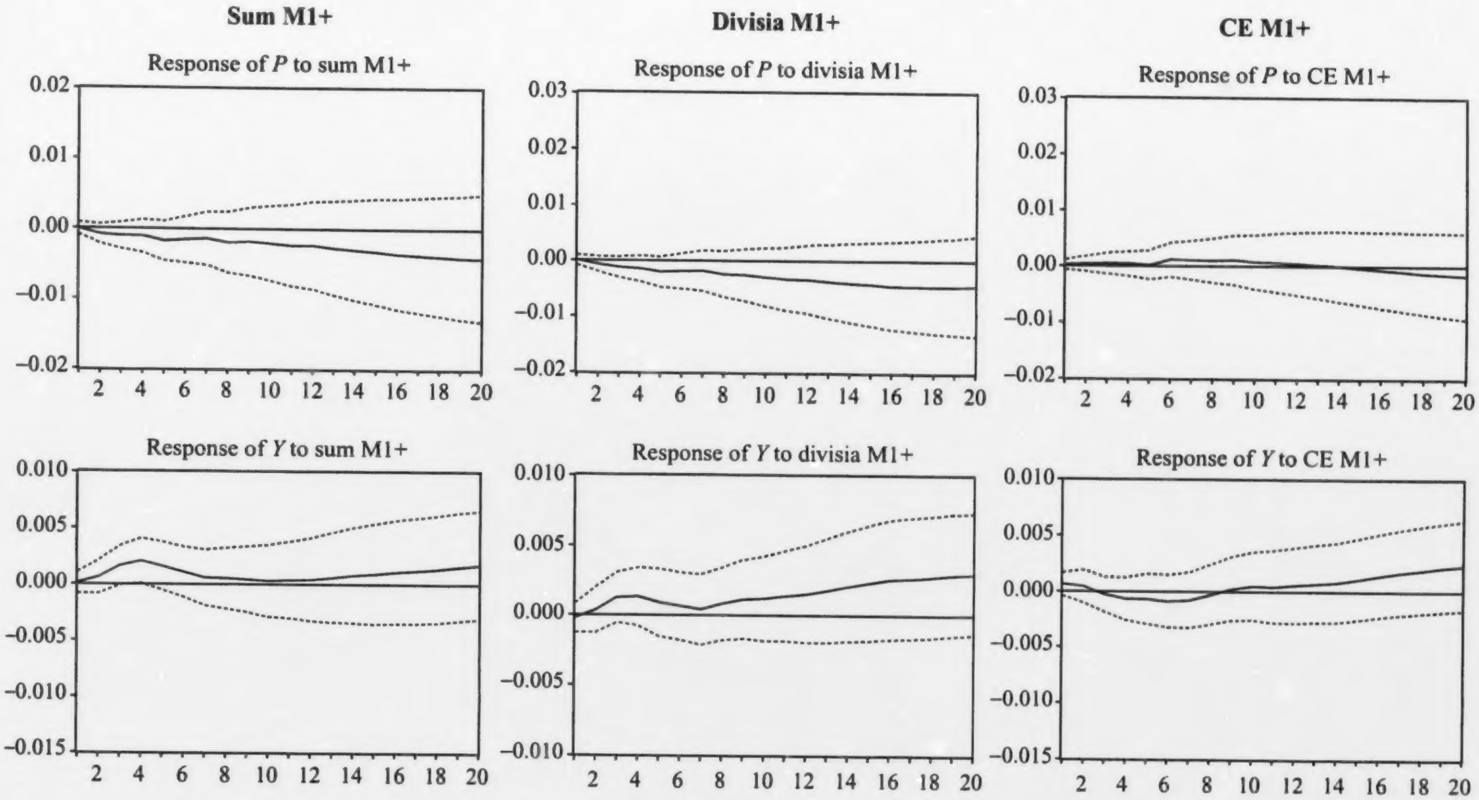
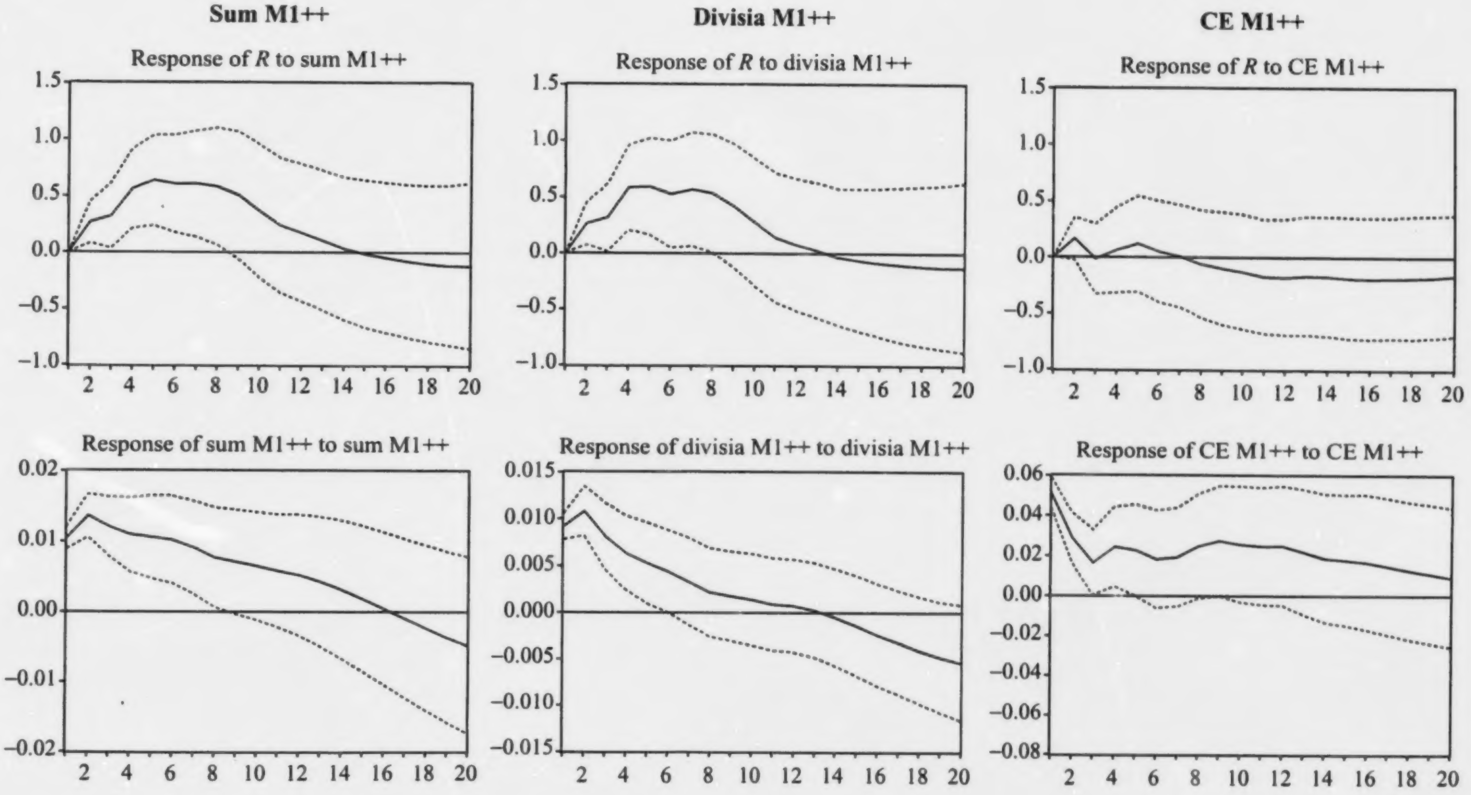


Figure 10
Impulse responses, {*R*, M1++, *P*, *Y*} models



Sum M1++

Response of *R* to sum M1++

Response of sum M1++ to sum M1++

Divisia M1++

Response of *R* to divisia M1++

Response of divisia M1++ to divisia M1++

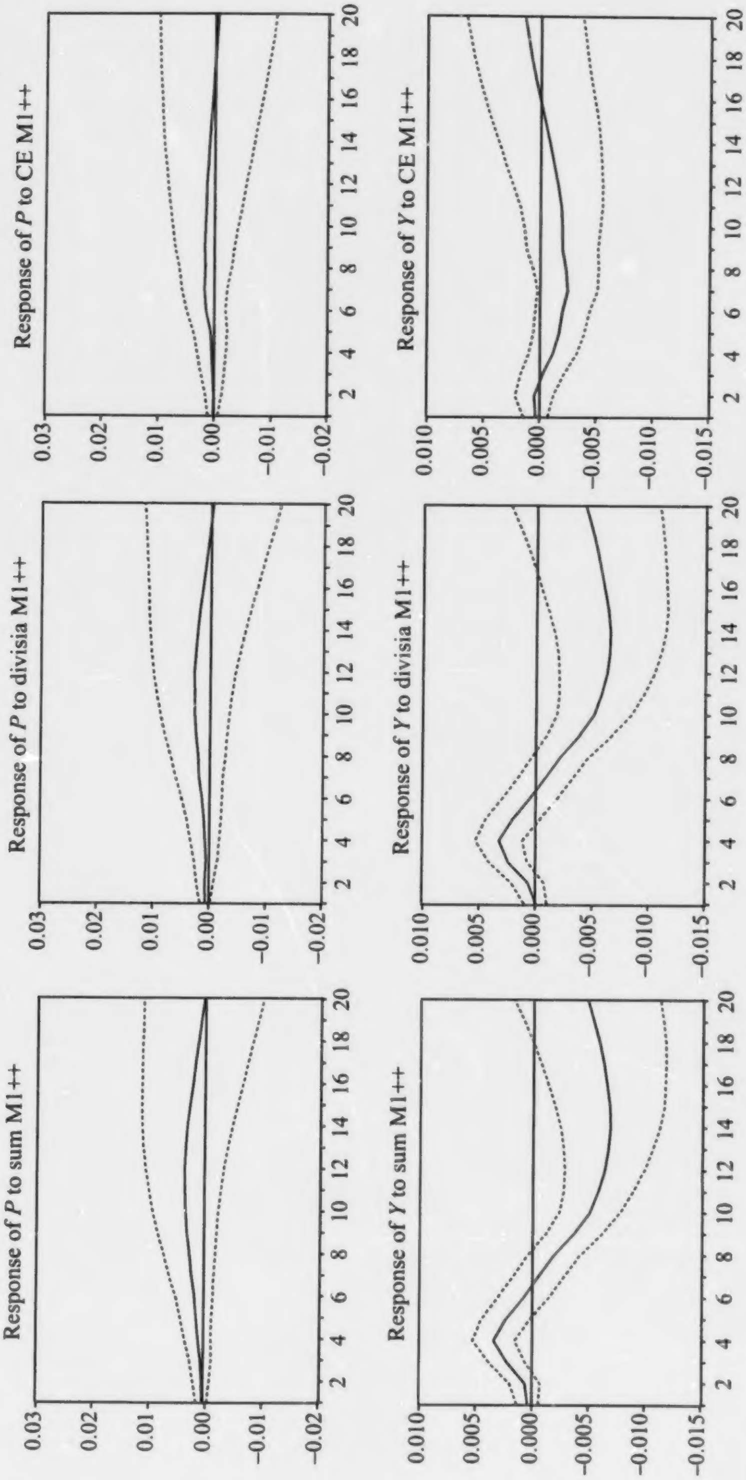
CE M1++

Response of *R* to CE M1++

Response of CE M1++ to CE M1++

(continued)

Figure 10 (continued)
Impulse responses, {*R*, M1++, *P*, *Y*} models



infer the effect of money on economic activity and to address disputes about the relative merits of different monetary aggregation procedures. We made our assessment using recent advances in the theory of integrated regressors and the single-equation approach, with the time-series properties of the data imposed in estimation and hypothesis testing. We also used the multi-equation VAR framework, which treats all variables as part of a joint process.

We find that the choice of monetary aggregation procedure is crucial when evaluating the relationship between money and economic activity. We provide evidence, consistent with that reported by Serletis and King (1993), that money, irrespective of how it is measured, does not cointegrate with prices or income. The evidence suggests that real money balances and velocity are nonstationary quantities and that monetary targeting will be problematic. However, Granger causality tests showed us that divisia M1++ is the best leading indicator of real output. Moreover, divisia M1++ causes changes in real output in VARs that include interest rates, and changes in divisia M1++ also explain a very high percentage of the forecast-error variance of output; changes in interest rates explain a smaller percentage of that variance.

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Discussion

Joseph Atta-Mensah

> It is a singular and, indeed, a significant fact that, although money was the first economic subject to attract men's thoughtful attention, and has been the focal centre of economic investigation ever since, there is at the present day not even an approximate agreement as to what ought to be designated by the word. The business world makes use of the term in several senses, while among economists there are almost as many different conceptions as there are writers upon money. (Andrew 1899, 219)

The Serletis and Molik paper renews the debate as to whether it is appropriate for central banks to use simple-sum monetary aggregates. Some monetary theorists, including Serletis and, notably, Barnett, have not been satisfied with the current computation of the monetary aggregates by central banks around the world, particularly the aggregates calculated by the summation of the monetary value of financial assets. By using a definition based on simple summation, the central banks imply that the aggregates' components all have the same degree of substitutability and liquidity. In an attempt to rectify this "anomaly," Barnett (1980) strongly advocated that central banks use statistical index number theory, such as divisia, to construct the monetary aggregates.

Serletis and Molik begin by providing a theoretical derivation of the formulas for constructing Barnett's (1980) divisia and Rotemberg, Driscoll, and Poterba's (1991) CE aggregates. Before I discuss the weaknesses inherent in these methods of constructing monetary aggregates, let me first shed light on how the divisia aggregates evolved.

Central banks initially defined money to include only financial assets used as a medium of exchange—currency and demand deposits—and started publishing data on two types of exchange media: currency outside the banking system and demand deposits at banks.[1] The sum of these two types of assets later became known as M1.

Friedman (1956, 1959), Friedman and Meiselman (1963), and Friedman and Schwartz (1969, 1970) proposed broadening the definition of money to include time deposits and savings deposits. This broader definition captured the "store of value" property of money. Friedman's main argument was that money served as a temporary abode of purchasing power and therefore bridged the gap between sales and payments.

Following these arguments the Federal Reserve System and other central banks started publishing broader monetary aggregates. However, these aggregates raise the problem of determining the degree of substitutability between the various financial assets that make up the aggregates. Although financial innovation has blurred the distinction between transactions- and savings-type assets, the assets that make up the broader aggregates do not have the same liquidity as currency. Batten and Thornton (1985, 30) argued that, "If different assets have different degrees of moneyness, we may wish to aggregate (add) them with respect to this homogeneous characteristic." However, the aggregates that the central banks now use are computed as simple summations. Thus, all assets in the aggregates are implicitly assumed to have the same degree of "moneyness." Some monetary theorists find this method of aggregation unacceptable and propose other methods.

One method, which Serletis and Molik build on, is that proposed by Barnett (1980) and much discussed in the literature. Barnett's method uses statistical index number theory to construct the monetary aggregates. He argued that this method gives true economic meaning to the aggregates. The approach uses aggregation theory to compute financial asset indices that reflect the total utility, relative to some base period, attributable to the monetary services obtained from these assets.

Consistent with Barnett's proposal, "superlative" monetary aggregates have been developed based on the index number theory.[2] This method defines money as a monetary quantity index. As Barnett noted, in this approach, aggregates are measured in terms of the flow of services that constitute the output of the economy's monetary transactions technology. Two superlative indices used in the literature are the Tornquist-Theil divisia and the chain-linked Fisher ideal.[3]

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[1] See Walter (1989) for a detailed summary of the evolution of the monetary aggregates in the United States.

[2] Diewert (1976, 1978) introduced these indices to the literature, suggesting that an index is superlative if it is exact for some aggregator function; in other words, if a close correspondence exists between the aggregator function and the index number formula.

As Serletis and Molik mention, theoretically the superlative monetary aggregates are a significant improvement over the summation aggregates for several reasons. First, they measure the flow of monetary services in the economy, determining the flow by weighting the quantity of each component asset with its unique rental cost. The rental cost is the difference between the rate of interest on a pure store-of-wealth asset and each asset's own rate of return. Second, superlative indices are exact for flexible functional forms. Thus they avoid the restrictive assumptions required to justify the linear form of the summation aggregate. Third, superlative aggregates attempt to internalize the substitution effects of interest rate changes. Income effects are reflected in the form of utility or monetary service changes. However, changes in interest rates would, in the case of summation aggregates, induce both substitution and income effects.

Using the theoretical derivations, Serletis and Molik construct divisia and CE aggregates. Although I commend them for their "public service" in constructing these aggregates, I would like to point out some measurement problems with divisia and CE aggregates.[4] First, posted rates on deposits at financial institutions may exaggerate the effective rate that economic agents expect on their investments. Cockerline and Murray (1981) argued that minimum-balance requirements for certain accounts, early encashment penalties on some fixed-term assets, and other service charges all tend to reduce the measured own rates of return on monetary assets. These measurement problems are complicated further by the possibility that financial institutions cross-subsidize activities, such as varying service fees or interest rates as a customer does other business with the institution.

Second, computing rental prices for the divisia aggregate could be complicated by aggregating across assets with different maturity dates. For example, if the yield curve is downward-sloping, then current short-term interest rates will be higher than long-term rates. Hence, the rental price of some of the monetary assets may be negative as their own rates rise above those of the benchmark asset, which is generally proxied by a long-term asset. Since the rental price represents a measure of liquidity, it is meaningless when it is negative.

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[3] See Barnett, Fisher, and Serletis (1992) for other superlative indices and the exact formula for constructing each one.

[4] Barnett (1991) showed that the CE aggregate is a special case of the divisia aggregate. Hence, my comments on the divisia aggregates also apply to the CE aggregates.

Third, the method of constructing the superlative indices assumes that economic agents hold the optimal values of assets in their portfolio and makes no allowance for portfolio adjustment costs. However, in practice, investors constantly readjust their portfolio holdings in response to changes in interest rates. Since the superlative method measures the user cost of an asset by the difference between the asset's rate of interest and that of a benchmark asset, and since the portfolio adjustment costs are not captured in the interest rates, the "true" user cost is underestimated.

Fourth, when calculating any asset's user cost, one assumes that the benchmark asset is completely illiquid. This implies that an asset traded in secondary markets does not qualify as a benchmark, because in a secondary market that asset could be readily converted into more-liquid assets that could be used for transactions. In practice such assets are difficult to come by. Also, only benchmark assets with non-negative user costs must be chosen; a negative user cost would imply that economic agents are prepared to sacrifice some of the returns on a purely non-monetary asset in order not to receive monetary services.

Fifth, the weights or rental prices used in the superlative indices are very sensitive to changes in interest rates. Higher interest rates will increase the user cost of currency and therefore lead instantaneously to a higher weight. However, as the higher interest rates cause investors to hold less cash in their portfolios, the weight for currency will fall over time. On the other hand, if the amount of currency held by economic agents grows more rapidly than the amount of interest-bearing deposits, rising interest rates will instantaneously increase the weight for currency and reduce that for interest-bearing assets, leading to an increase in the superlative index growth rate. The superlative index could therefore be a misleading information variable for monetary policy-makers. One should be cautious when interpreting empirical results derived using superlative aggregates.

I shall now turn to Serletis and Molik's empirical work. Their empirical focus is the investigation of the roles of simple-sum, divisia, and CE aggregates in Canadian monetary policy. They use H-P filters to examine the correlations between the aggregates and income and prices. They also conduct integration, cointegration, and Granger causality tests. Their main results are as follows. First, using the H-P filters the authors find that M1, M1+, and their divisia counterparts are the only aggregates that lead real GDP. Second, they find all the monetary aggregates, prices, and nominal and real GDP are integrated of order 1. Third, they find no cointegration between each of the monetary aggregates on the one hand and either the price level or nominal or real GDP on the other hand. Fourth, using the Granger causality tests they find that none of the monetary aggregates is a leading indicator of inflation, that divisia M1 is the best leading indicator of nominal income, and that divisia M1++ is the best leading indicator of real income. From these results they conclude that monetary targeting in Canada would not be appropriate.

The first issue I will take up with Serletis and Molik on their empirical work is the substitutability of the financial assets that make up each aggregate. One criticism of the current monetary aggregates is that they treat all constituent financial assets as perfect substitutes for money; however, studies have shown that few financial assets actually do appear to be good substitutes.[5] I believe this criticism applies to Serletis and Molik's paper as well, since in constructing their aggregates they fail to test whether the components of each aggregate are substitutes.

Barnett (1982) argued that it is important that all the components in an aggregate are close substitutes in order to ensure that monetary assets are separable from non-monetary goods. He argued that a monetary aggregate can exist if, and only if, there is a subset of monetary goods that is at least weakly separable from non-monetary goods. Weak separability implies that the marginal rate of substitution between any two monetary goods in a subset is independent of other goods not in the subset. Thus, as Swofford and Whitney (1991) pointed out, this condition ensures that monetary aggregates are not affected by changes in the composition of spending on non-monetary goods. In other words, the monetary aggregate depends on total income and not on the composition of expenditures.

Belongia and Chalfant (1989) and Swofford and Whitney (1992) recommended using Varian's (1982, 1983) nonparametric-revealed-preference conditions to test whether a monetary aggregate satisfies the condition of weak separability. Varian's test of weak separability has three steps. The first is to check whether the data set satisfies the consistency condition of the generalized axiom of revealed preference (GARP). The second is to check any sub-utility for consistency with GARP. The third is to verify whether the data set meets certain sufficient conditions.[6] A well-behaved utility function can serve as an aggregator function if the financial data obey the GARP axiom.

I would also like to comment on Serletis and Molik's result that money neither correlates nor leads inflation. This very puzzling finding goes against the old adage in monetary economics that inflation is a monetary phenomenon. I believe that they obtain their results because they examine the relationship between the aggregates and prices using quarterly growth rates. As we know, quarterly growth rates are more volatile, or "noisy," than are annual rates. Consequently, quarterly growth rates do not easily yield meaningful relationships in the data. Moreover, monetary policy actions as we know them affect prices only after a considerable lag, generally thought to be about six to eight quarters. So the correlation between money and prices can best be observed using their year-over-year growth rates.

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[5] See Belongia and Chalfant (1989) for a summary of some of the studies.

[6] See Swofford and Whitney (1991, 1992) for the test of some of the sufficient conditions.

Furthermore, the literature is filled with results that demonstrate strong relationships between various definitions of money and inflation. Here at the Bank our work shows that money is important in the price formation process. Engert and Hendry (1998) and Adam and Hendry (2000) found that an M1-based vector-error-correction model (VECM) provides considerable leading information about inflation, forecasting the 8-quarter inflation rate with relatively small errors. Also, a structural VAR analysis conducted by Kasumovich (1996) and Fung and Kasumovich (1998) shows that money plays an active role in transmitting monetary policy. In all these models a monetary policy shock disturbs the relationship between the money stock and long-run demand, leading to a long adjustment process in which prices adjust to restore monetary equilibrium. McPhail (2000) also found that broad money, in particular M2++, is a useful predictor of inflation at a horizon of one to two years. In sum, this body of work identifies a strong relationship between money and inflation; an excessive expansion of money would cause inflationary pressures to build up.

Overall I find that the empirical work in the paper does not go very far. Serletis and Molik use various econometric techniques, but their main purpose is to examine the correlations in the data, the order of integration, and the direction of causality between the variables. Since they seek to compare the empirical performance of the simple-sum monetary aggregates against those of their divisia and CE counterparts, I would have liked to see the authors also compare the aggregates' stability in money-demand equations and their ability to forecast macroeconomic variables, such as real GDP and inflation. Such analysis would compare the aggregates more completely.

If monetary aggregates are to be used effectively in conducting monetary policy, the demand function for the aggregates must be stable. Stability requires that the demand for the aggregates be a systematic function of small macroeconomic variables, such as income and interest rates; thus, changes in the aggregates are predicted in terms of changes in the variables. Stability also means that the parameter estimates of the demand functions do not change significantly when the function is re-estimated with an additional data set.

At the Bank we have been able to estimate stable long-run money-demand functions for the simple-sum narrow and broad aggregates. Using Johansen-Juselius methodology, Hendry (1995) identified a unique stable long-run money-demand function for M1. McPhail (1993, 2000) has also used the Johansen-Juselius methodology to find stable long-run demand functions for broad monetary aggregates. An interesting exercise would be for Serletis and Molik to estimate the demand functions for the divisia and CE aggregates and assess the stability of these demand functions. As well, if the estimated demand function for these aggregates is stable, the authors could compare the forecasting ability of these aggregates in VECMs to that of their simple-sum counterparts.

As I pointed out earlier, theoretically the superlative aggregates are unquestionably far superior to their simple-sum counterparts. So why do central banks, including the Bank of Canada, continue to use simple-sum aggregates? In my view this paper and proponents of the superlative aggregates have not shown enough empirical evidence to warrant abandoning simple-sum aggregates. Overall, the work at the Bank by Cockerline and Murray (1981), Hostland, Poloz, and Storer (1988), and Longworth and Atta-Mensah (1995) does indicate that, on the basis of the in-sample fit of indicator models, the out-of-sample forecasts by indicator models, the specification of money-demand functions, and the temporal stability of money-demand functions, the simple-sum aggregates are empirically superior to their divisia or Fisher ideal counterparts.

The answer to this debate may lie between the simple-sum and the superlative aggregates. However, in constructing reliable monetary aggregates, central banks must be clear as to what assets qualify as money. Unfortunately, neither the literature on monetary economics nor traditional textbooks adequately define money. Also, financial innovations have so fundamentally altered the characteristics of many monetary assets that it is very difficult to find a precise definition of money. Indeed, a universal definition may be beyond our grasp. As Friedman and Schwartz (1970, 137) noted,

> The definition of money is to be sought for not on grounds of principle but on grounds of usefulness in organizing our knowledge of economic relationships. "Money" is that to which we choose to assign a number by specified operations; it is not something in existence to be discovered, like the American continent; it is a tentative scientific construct to be invented, like "length" or "temperature" or "force" in physics.

I suggest that, in the absence of a universal definition, central banks define "money" pragmatically in a manner that will help them conduct a sound and effective monetary policy. Central banks could define money to include assets that are accepted as means of payment, liquid assets, and other types of liabilities held by financial institutions. These assets need not be tangible, but when used, should not generate debt or a repayment obligation. Such a definition excludes from the money stock all forms of credit. On the basis of this definition, monetary aggregates could be classified into transactions and savings aggregates. Furthermore, based on chosen criteria, these assets should perform well empirically.

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Discussion

Seamus Hogan

Serletis and Molik's paper is one of a number in this conference that address what is perhaps the fundamental question of empirical monetary economics: In a world in which there are many monetary assets that are not perfect substitutes, what empirical measure of money best corresponds to the simple *M* of textbook monetary theory?

An important contribution of their paper is to combine two strands of the literature dealing with this question. The first strand focuses on what assets to include in the monetary basket; that is, it addresses the binary question of whether a particular asset is money or is not. Typically this involves ranking assets according to their liquidity and then choosing where along that liquidity continuum to draw the line between what is money and what is not. The second strand, of which divisia and CE indices are examples, makes the binary question more continuous by taking a broad basket of assets but allowing the more-liquid assets to have a greater weight.

The approach to the latter strand does not encompass the approach to the former one: The weights in divisia and CE indices are derived from theory rather than being estimated and so do not allow weights of 0 and 1 as special cases. For each of these index classes, therefore, there remains the question of what to include in the basket. A strength of their paper is that they consider a simple-sum aggregate, a divisia index, and a CE index for *each one* of five different monetary aggregates. This requires a lot of work, but it enables us to discern to what extent the weighting scheme rather than the choice of basket is the source of the results.

The value of this work becomes apparent when looking at their Figures 1 to 5. For all aggregates broader than M1, the CE index behaves very differently from the other two measures, particularly in the 1990s. Perhaps it goes beyond the scope of their paper, but I would have liked to have seen more follow-up on this: What is it about CE indices and about the 1990s that causes this divergence? It would also be interesting to know whether the CE measures have more or less explanatory power in the various regressions for the 1990s in order to see whether the pattern clearly observable to the eye conveys useful information about what the best measures of money are.

The second thing I like about their paper is its empirical focus. The theory underlying the variable-weight indexes is appealing, but it depends on a number of assumptions about how well we can measure the *effective* relative prices between different monetary assets, how well individual money-demand functions aggregate, and so on. Ultimately, although theory can suggest different candidates to try, the empirical question as to what is the best real-world measure of money has to be determined empirically.

I think, however, that Serletis and Molik have taken the strictly empirical approach too far. Before going to the data to ask what is the best measure of money, we have to first ask the question: best at what? For instance, are we looking for the measure that is the best leading indicator of inflation or income, that is the best measure of the stance of monetary policy, or that meets some other criterion? The answer to this question should suggest the best way to interrogate the data and hence how to interpret the results. I would have liked to see the authors orient their paper more along these lines rather than leaving the data to speak for themselves. Serletis and Molik present their results in a purely *statistical* dimension rather than in an *economic* dimension relevant to the motivating question. For instance, some insight into which money measure is the best leading indicator of inflation is found in their Granger causality tests; however, these results are presented purely in terms of p values for falsely rejecting the null hypothesis of no causality. Although this provides some useful information, it does not directly address how good a leading indicator each measure of money is. It would have been interesting to see this information supplemented with the results of some out-of-sample forecasts, perhaps based on rolling samples.

Overall, their paper presents a wealth of information that raises many interesting questions. I hope that they and others will continue down the road they have started to further explore these issues.

General Discussion

In his response to the discussants, Serletis reiterated the need to look beyond simple-sum aggregates to a more general approach, which has long been advocated by authorities such as Friedman and Schwartz (1970); however, he conceded that there are complications involved in constructing and using divisia aggregates. In particular he noted that the judgment needed in the choice of own rates and user costs often makes it difficult for other researchers to replicate results. Also, institutional changes such as bank mergers and acquisitions of near-banks may lead to difficulties in constructing consistent time series.

Alain Paquet raised three concerns. First, only pair-wise cointegration is examined in Serletis and Molik's paper. He argued that you cannot conclude whether the aggregates do or do not have desirable properties based merely on results from pair-wise cointegration tests. Instead, one should use more variables in the tests, since doing so may change the results. Second, the VAR is estimated in levels. If the data are nonstationary the distribution of the Granger-causality statistics would be non-standard and the reported p values would be biased. Also, estimating the VAR in levels with integrated variables and a finite sample can result in significant biases for the estimated impulse responses (for example, see Phillips 1998). Therefore it may be more appropriate to estimate the VAR in differences, or alternatively, use a VECM. Third, the results may be very sensitive to the ordering used in the Choleski decomposition to identify the VAR. An alternative identification could use long-run restrictions; e.g., the neutrality of money, a concept that Serletis and Koustas (1998) support. In conclusion Paquet suggested that more work be done to test the robustness of the results.

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* Prepared by Jamie Armour.

Pierre Duguay was puzzled by the asymmetric treatment of demand deposits versus other deposits regarding the own rate of return. Serletis and Molik adjusted implicit returns for services only for demand deposits and not for chequable notice deposits. Duguay also pointed out a contrast between their Figure 1 and Figure 1 in the Aubry-Nott presentation. The big shifts that occur in the simple-sum M1 in the Aubry-Nott paper are not apparent in the divisia aggregate in Serletis and Molik's paper. Duguay conjectured that this was related to the behaviour of the relative value of the calculated yields.

A theoretical question about the definition of transactions money was raised by Shamik Dhar. He noted that in the U.K., divisia indices are highly correlated with sum M4 because movements in the two series are dominated by non-bank financial institutions. The M4 aggregate largely represents "financial transactions demand" for money. If economists were more interested in "goods and services transactions demand" for money, then they might regard the assets of non-bank financial institutions as less important.

Robbie Jones was interested in how term-structure models would affect the calculated rates of return in their paper. For example, how would you interpret an inverted yield curve? Differences between the rates of return on short and long assets would usually reflect expected changes in short rates. Jones wondered if it would be possible to use an ex post return to holding long-term bonds for 90 days. Serletis replied that all the returns used in the paper are risk-adjusted and that the benchmark rate is the maximum rate over the sample.

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The M1 Vector-Error-Correction Model: Some Extensions and Applications

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Charleen Adam and Scott Hendry

> Conducting monetary policy . . . is akin to driving without full vision—perhaps like driving in a rainstorm with defective windshield wipers. It can be done, but only very carefully. (John Crow, Eric J. Hanson Memorial Lecture, 1988)

> The Fed's dilemma is like that of a tugboat captain pushing a long string of barges in a dense fog; the awkward load is difficult to pilot. He needs to start his turn half a mile before the bend. But he can't see the bend until it's too late. (Allan Murray, *The Wall Street Journal*, 1989)

Introduction

Monetary policy-makers face a difficult task when evaluating the current state of the economy and deciding what actions are needed to achieve their objectives, such as keeping inflation within a given range. Because long and variable lags exist between a monetary policy action and its effects on economic variables, policy-makers need a way to assess whether their actions are having, or indeed will have, the desired effect.

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[*] We would like to thank, without implicating, Bob Amano, David Andolfatto, Kevin Clinton, Walter Engert, Chuck Freedman, Kevin Moran, and Jack Selody for their useful comments on earlier drafts of this paper. Many thanks to Pierre Duguay for assistance in finding the John Crow quotation. The Murray reference is from Dorfman.

Economists at the Bank of Canada use inflation forecasts, in addition to other variables considered to have leading-indicator properties, to inform policy-makers' views on the current and future state of the economy. Some of these variables are new orders and shipments, housing market activity, inflation, and various money and credit aggregates. Since no one single indicator is superior to all others, a good strategy is to monitor many variables to try to ensure that the best signals about the economy are being considered. This strategy also extends to models. Given that a model is simply a collection of assumptions or behavioural rules about the way an economy works, economists maintain several models for forecasting or conditional projections.[1]

Economists at the Bank have pursued modelling strategies along a continuum anchored at one end by purely theoretical approaches and at the other end by purely empirical approaches.[2] The model we use in this paper is an M1 vector-error-correction model (VECM), which could be described as lying somewhere between the middle of the continuum and the purely empirical end. At the heart of this model is a long-run money-demand function. Several extensions have been made to the basic model Hendry (1995) presented to add more theory (or structure) to it in order to make it more useful for conducting counter-factual analysis: for asking "what if" questions.

Sections 1 and 2 provide some background and context for the M1 VECM and discuss the changes made to Hendry's original model. Section 3 details why gross M1 is no longer the preferred measure of narrow money for the VECM and outlines how adjusted M1, the preferred measure, is constructed. Section 4 discusses the identification of policy shocks in the VECM, and section 5 lays out the framework for using information from models to inform policy. Section 6 provides some direction for future work.

1 Background

Inflation is essentially a monetary phenomenon. In the long run an excess creation of money is bound to lead to inflation. In the short run the links may not be as tight. After an unsuccessful attempt at using money-growth targets to reduce inflation in the 1970s both here in Canada and in the United States, many models now used to guide policy advice assume that money plays only a passive role and may be ignored for all practical purposes because the central bank and commercial banks are assumed to simply supply money passively in accordance with agents' demand. Consequently, no causal role is given to money in these models of inflation. This paper uses an active-money paradigm in which money causes inflation. However, in this model, money's causal effect on inflation does not depend on using money as the instrument of monetary policy, as is the case in many theoretical models. A very short-term interest rate such as the overnight rate can be considered to be the instrument of monetary policy, consistent with the Bank of Canada's operating procedure. In responding to changes in the overnight rate, financial intermediaries make loans to agents in the economy and hence create deposits. These agents then transact with other agents using the newly created balances, leading to changes in the level of aggregate activity and prices. The underlying premise is that agents have a long-run demand for money, and the amount of money an agent actually holds fluctuates around these desired money holdings. For the purposes of the discussion below, the difference between actual money supply and estimated long-run money demand (using the long-run parameters but evaluated at the current values of the variables in the long-run demand function) is called the money gap.[3]

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[1] Engert and Selody (1998) and Berk (1997) made excellent arguments for the use of multiple models in formulating monetary policy. No single model can capture all aspects of the economy, so it is useful for policy-makers to have several different models summarizing different views or aspects of the economy.

[2] Thanks are due to Kevin Moran and Jack Selody for suggesting this analogy.

Laidler (1999) discussed the passive- and active-money views, drawing on the buffer-stock theory to explain why people may temporarily be off their long-run money-demand function.[4] For example, suppose an agent receives an unanticipated lump sum of money. Information and transaction costs are involved in deciding what to do with the money and then doing it. Hence, it is optimal to take some time to arrive at a decision, and consequently at any time an agent's actual holdings of transactions money might differ from his or her desired long-run holdings of money. That is, actual money holdings fluctuate around the desired level (i.e., long-run demand for money), much as a firm's inventories fluctuate around some level of desired inventory holdings. A firm or individual with money holdings exceeding the desired level of money balances will act to get rid of these excess balances by transacting with other agents in the economy. An excess aggregate supply of money can translate into inflationary pressure in much the same way that an excess demand for goods does; too much money chases too few goods. Hence, a positive money gap, where the stock of money exceeds the aggregate long-run demand for money, is associated with periods of rising inflationary pressure, and a negative gap, where the stock of money is less than long-run demand for money, is associated with disinflationary pressures.

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[3] In this sense, what is being evaluated is the difference between actual money and today's value of the long-run demand for money. The long-run money-demand function could also be evaluated at the long-run values of the variables in the long-run demand function, but doing so causes the money gap to lose most of its predictive power. This is likely because rather than evaluating money supply at its actual value, the model should include some notion of long-run supply. Identifying the money-supply process is an area for future work.

[4] Laidler's (1999) discussion focuses on narrow, or transactions, money.

The adjusted-M1 VECM presented in this paper is an extension of work done by Hendry (1995), who estimated a unique long-run cointegrating vector between M1, output, prices, and a short-term interest rate. The vector can be thought of as a long-run money-demand function. Since money demanded does not have to be equal to money supplied at each point in time (though they must be equal in the steady state), the error-correction term of the VECM can be thought of as a money gap, which has been shown to have predictive power for inflation.[5]

2 Details of the VECM

The model used in this paper is similar to Hendry's original model in that it estimates a unique and stable long-run cointegrating vector between quarterly data for nominal M1, real output, the consumer price index, and a short-term interest rate. This vector can be also considered to be a long-run money-demand function. (See the appendix for more details on the model.)

The Johansen-Juselius (1990) methodology was used to estimate the long-run cointegrating vector from a VECM of the form

$$\Delta X_t = \Gamma(L)\Delta X_t + DZ_t + \alpha\beta'[X_{t-1}], \tag{1}$$

where X_t is a vector of endogenous variables (i.e., money, output, prices, and interest rates), $\Gamma(L)$ is a matrix of parameters for a fourth-order lag process, Z_t is a vector of stationary exogenous variables including seasonal dummies, and D is the matrix of parameters associated with the exogenous variables. The α parameters measure the speed at which the variables in the system adjust to restore a long-run equilibrium, and the β vectors are estimates of the long-run cointegrating relationships between the variables in the model.

This system was found to have a unique stable long-run cointegrating relationship between money, inflation, output, and interest rates. Unitary price elasticity is imposed (i.e., prices move one for one with changes in money), and the long-run coefficient on output is around 0.5 while that on the interest rate is about –0.04, both of which are consistent with previous work.[6]

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[5] Armour et al. (1996) and Engert and Hendry (1998) found the VECM to be a good inflation-forecasting model at horizons of one to two years. As well, Fung and Kasumovich (1998) found that following an expansionary monetary policy shock, a positive money gap opens up, followed by an increase in prices.

[6] The restriction of unitary price elasticity in an unrestricted regression was not rejected.

However, the estimated short-run parameters of Hendry's original model (i.e., the α parameters as well as the coefficients on the lagged endogenous variables) were unstable in that they varied greatly over the sample period. Consequently, a number of exogenous variables were added to improve the estimates. One of the exogenous variables included is a measure of the output gap calculated using potential output from the Bank's Quarterly Projection Model (QPM), which measures potential using an extended multivariate filter (see Butler 1996 for details on this approach). Other exogenous variables added are the Can$/US$ spot exchange rate, the U.S. 90-day commercial paper rate, the U.S. inflation rate, the change in non-personal notice deposits post-1980, and a permanent shift dummy for the early 1980s. The 1980s shift variable is interpreted as a proxy for the financial innovations that occurred at chartered banks at that time.[7] Many other variables, such as daily-interest account rates and dollar values, the yield curve, and the volatility of long-term rates were also tried as proxies for these innovations; however, none of them successfully eliminated the need for the 1980s dummy variable.

Including non-personal notice deposits in the model as an exogenous variable was an attempt to internalize the shift between demand and notice deposits that has been occurring over the 1990s. Reserve requirements on demand and notice deposits were eliminated in the early 1990s, leading to some redistribution of funds on the part of agents (mainly business customers) out of notice deposits and into demand deposits. The redistribution has increased the growth rate of M1 in recent years; however, while the increase in M1 growth has been associated with some acceleration of real GDP growth, it has not spilled over into increased inflation to date. The shift between notice and demand deposits is not the only innovation to affect the M1 aggregate,[8] and this is why adjusted M1, rather than gross M1, is used in the model. The construction of adjusted M1 is discussed in section 3.

Some equilibrium conditions have been imposed on the model to force it to a particular steady state. In the steady state, potential output growth is assumed to be 2.3 per cent, inflation is 2 per cent, and money growth is 3.2 per cent, as implied by the long-run money-demand parameters and the assumptions on output and price growth. The steady-state overnight rate is about 4.9 per cent and is based on the historical relationship with U.S. interest rates.

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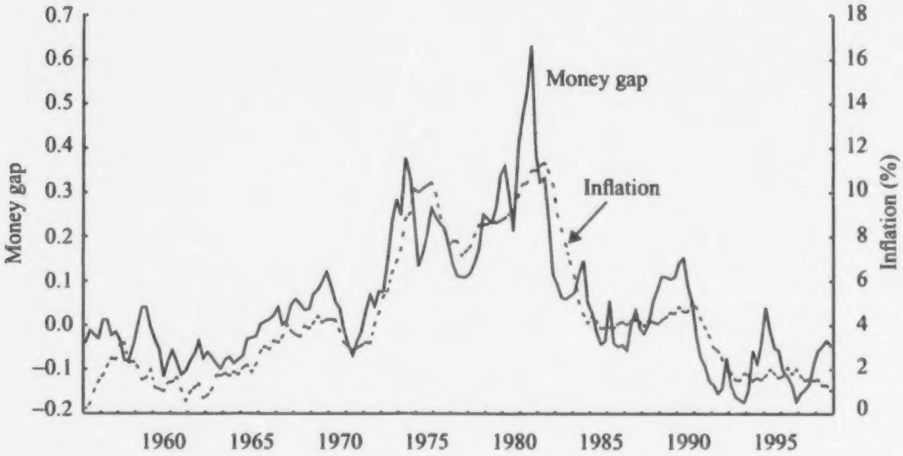
[7] See Freedman (1983), Gomme (1998), and Aubry and Nott (2000) for discussions of some of these innovations.

[8] See Bank of Canada (1998), Atta-Mensah and Nott (1999), and Aubry and Nott (2000) for discussions of the innovations affecting M1 in the 1990s.

Figure 1
Money gap vs. 8-quarter inflation rate



As discussed in section 1, the difference between actual money supply and estimated long-run money demand is called the money gap. The money gap has moved very closely with actual inflation over the last 40 years (see Figure 1) and helps the model to predict inflation.

The main differences between the M1 VECM presented in this paper and Hendry's original are that the current model uses adjusted M1 (discussed in section 3) rather than gross M1, and the overnight interest rate rather than the 90-day commercial paper rate. The overnight rate has been the policy instrument in Canada since 1994, and there is evidence that the overnight rate provides a good way to measure monetary policy in Canada over a much longer period (see Armour, Engert, and Fung 1996). Moreover, because the overnight rate is highly correlated with the 90-day commercial paper rate (the correlation since 1956 is 0.98), changing the short-term interest rate used in the model had no significant effects on the estimated money-demand function or the model's forecasting performance.

3 Dealing with Financial Innovations in Narrow Money

In Canada, changes in real M1 growth are correlated with changes in real GDP growth about two quarters in the future.[9] M1 growth is also correlated with changes in prices about eight quarters in the future.[10] However, in the 1990s the relationship between money and other economic variables appears to have shifted, possibly in relation to the "restructuring" of the Canadian economy after the 1990–91 recession. This shift could also be related to the change in monetary policy to a regime of explicit inflation targeting. A last explanation could be that the many financial innovations in the 1990s appear to have changed the nature of deposit accounts.

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[9] See, for instance, Bank of Canada (1999, 29).

[10] As discussed in Hendry (1995) and Armour et al. (1996).

Given this last possibility, the definition of narrow money for use in the VECM was re-examined.[11] Narrow money is generally considered to be money used in transactions for goods and services. In Canada, narrow money is currently defined as M1, which comprises currency, personal chequing accounts, and current accounts. Over the period 1992 to 1994, reserve requirements on accounts were phased out, reducing the distinction between notice and demand accounts.[12] Also, the improvement in electronic financial services in recent years and the increased popularity of debit cards, ATMs, and telephone/PC banking have led agents to economize on their cash balances and enabled them to more easily access non-M1 accounts for transactions purposes. These technological improvements seem to have increased the degree of substitutability between cash and demand or notice deposit accounts, and consequently a broader definition of transactions money might be more appropriate in an electronic world. As well, most of the products financial institutions currently offer have joint transactions and savings characteristics. Thus, some proportion of these balances does not really belong in a transactions money measure and should be excluded. The problem is to come up with a reasonable way of approximating this proportion.

In Canada over the period 1980 to 1982, another series of financial innovations introduced instability into the parameters of the model's cointegrating vector. However, the 1980s innovations tended to simply move money from (M1) demand deposits to (M2) notice deposits. In order to deal with an environment of high interest rates and changing reserve requirements, banks offered customers incentives to move their accounts from ones that were costly for the banks to maintain (demand deposits) to ones that were more cost-effective for the banks (notice deposits). Banks introduced innovations such as daily-interest savings and daily-interest chequing accounts to motivate consumers to switch from non-interest-bearing demand accounts to interest-bearing notice accounts. The shift in the 1990s has not only been related to a switch back from notice to demand accounts owing to the reduction and eventual removal of reserve requirements for demand accounts, but also to the advent of technological changes, as more types of accounts now have the characteristics of transactions money.

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[11] Aubry and Nott (2000) examined the conceptual issues of what should be included in a measure of narrow money.

[12] Reserve requirements were higher on demand deposits included in M1 than on notice deposits excluded from M1. As a consequence, beyond the essentially irrelevant withdrawal-notice requirement, the distinction between demand and notice accounts has become meaningless. So far, this innovation seems to have affected mainly business accounts. Banks have begun to pay more attractive rates of interest on current accounts, and businesses have shifted some of their funds into those accounts.

Adjusted M1 is a model-based measure of money that was constructed for this paper specifically to correct the VECM instability and estimate the size of the distortion in M1. This was done in two steps.

First, the money-forecasting equation from a gross-M1 VECM (estimated from 1956 to 1993) was used to forecast M1 growth from 1992Q1 to 1999Q1, using actual values for all other variables in the model. It yielded a time series we called "distortion-free" money. This series is an estimate of what M1 would have been had the data-generating process not changed in the 1990s.

Second, in order to relate the distortion-free money series to the observable money data, it was regressed on all the components of M1++ (gross M1 plus all notice deposits). Because the coefficients were similar on some components that could reasonably be thought of as having the same sort of characteristics or users, these components were grouped together to reduce the number of parameters to estimate in order to improve efficiency, given the small sample size.

3.1 Calculating adjusted M1

Adjusted M1 is calculated as follows:

$$\begin{aligned} \textit{adjusted M1} &= 1.58\,(\textit{currency}) + 0.28\,(\textit{non-personal}) \\ &\quad \text{for 92Q1 to 94Q3} \end{aligned}$$

$$\begin{aligned} \textit{adjusted M1} &= 1.19\,(\textit{currency}) + 0.22\,(\textit{non-personal}) \\ &\quad + 0.15\,(\textit{personal}) \text{ for 94Q4 to 99Q1,} \end{aligned}$$

where *non-personal* is the sum of current accounts and non-personal notice deposits, and *personal* is all personal notice deposits.[13]

Adjusted M1 differs from M1 in two respects:

1. Choice of components: Adjusted M1 includes notice accounts but not personal chequing accounts (PCAs) because the latter include investment dealer accounts (which today represent more than half of PCAs). The investment dealer accounts appear to be held predominantly to purchase

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[13] The sample was divided into two subperiods to reflect the fact that the parameter estimates after 1994Q3 are substantially different from those prior to it.

Figure 2
Income elasticity from rolling regression

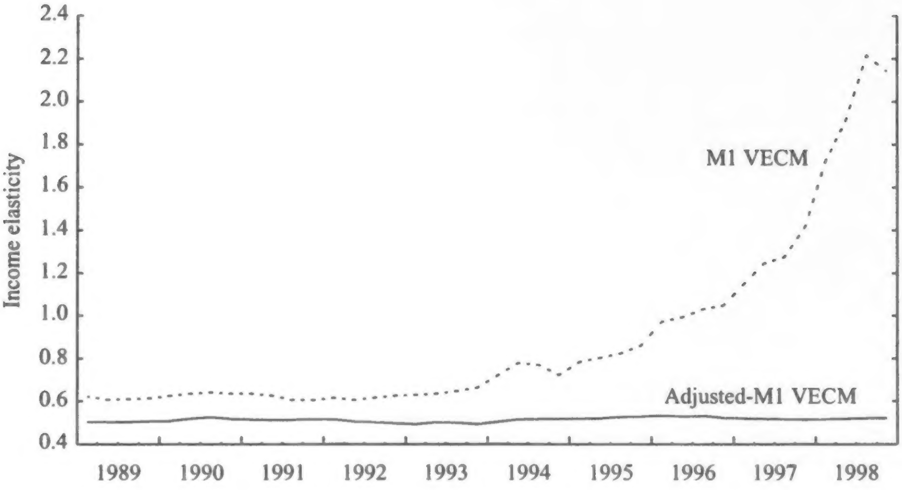


Figure 3
Interest rate semi-elasticity from rolling regression

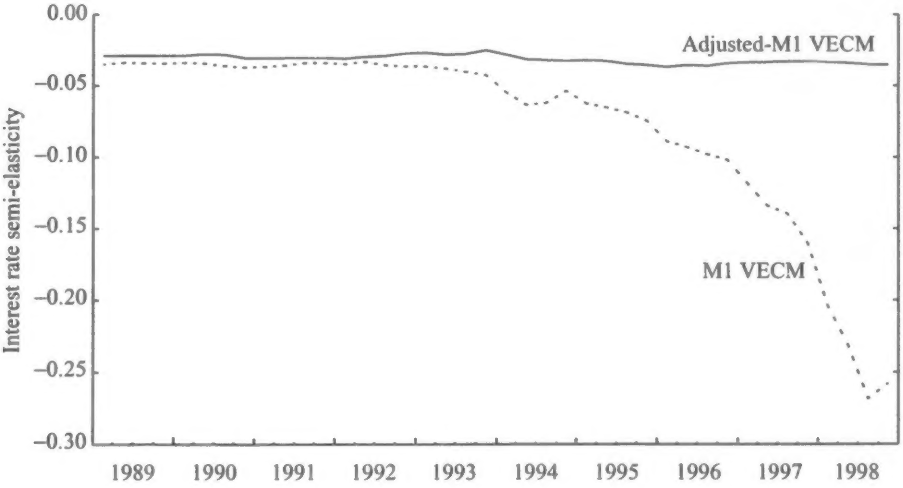


Figure 4
Year-over-year growth rate of gross M1 vs. adjusted M1

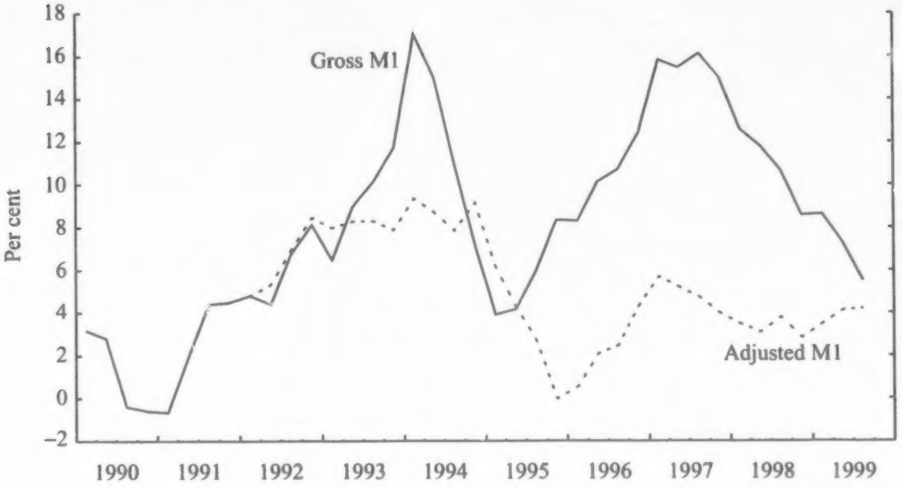
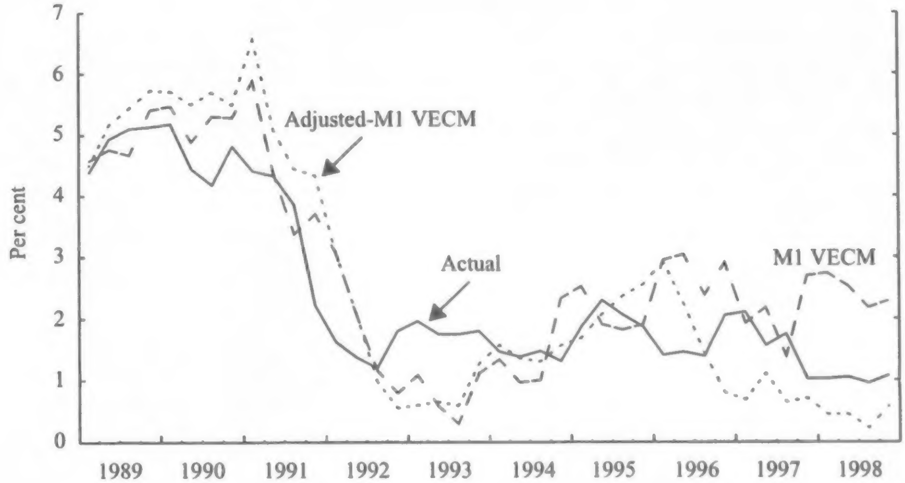


Figure 5
Forecast and actual 4-quarters-ahead 4-quarter inflation rate



financial assets such as mutual funds, stocks, and bonds, rather than to buy goods and services, and therefore should probably be classified within some broader aggregate that is defined as store-of-wealth money rather than in our measure of transactions money.

2. Choice of weights: M1 uses fixed weights of 1 on each of its components, whereas the weights of adjusted M1 differ from 1 based on the estimation results. Adjusted M1 also permits the weights to change at discrete points in the sample.

Given the small size of the sample, as well as the extent to which the parameters have shifted over time, the weights reported here should be treated with caution. This issue will be discussed in more depth later.

The primary purpose of this exercise was to correct the VECM instability, and Figures 2 and 3 clearly show that the adjusted-M1 VECM has more stable parameters, by design, than the original M1 VECM.

Figure 4 shows that the growth rate of adjusted M1 has been much weaker than that of gross M1 over much of the 1990s. However, by design, adjusted M1 is more consistent with the actual movements of prices, output, and interest rates.

In spite of this lower growth rate the inflation forecasts of the adjusted-M1 VECM are similar to those of Hendry's original M1 VECM (see Figure 5). This is likely because the M1 VECM version had shifted parameters to offset the high M1 growth and still obtained moderate inflation forecasts. The adjusted-M1 VECM uses lower money growth but more-stable parameters to obtain a reasonably similar forecast through most of the sample, with a root-mean-squared error (RMSE) of 0.91 compared to an RMSE of 0.94 for the original M1 VECM.

3.2 Why choose this approach?

The instability in the long-run parameters in Hendry's model could have been corrected with dummy variables, but this would not have provided any information about the sources of the instability.[14] The approach taken in our paper is also more flexible than the dummy-variable approach in that it is not necessary to impose a priori when the distortion should end. As Figure 4 shows, the distortion to M1 (the difference between the growth rate of gross M1 and adjusted M1) has been about 6 to 7 per cent per year over the last three years. In this volume's paper by Aubry and Nott (2000), distortions related to specific institutional events were examined (the substitution of funds from notice accounts to current accounts at some banks, the effects of dealer accounts in PCAs, and the introduction of the $2 coin), and the estimate of the size of the distortion was found to be only about 2 per cent per year.[15]

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[14] One problem with the dummy-variable approach is that it would treat the distortion in all components as equal. Our approach allows for the possibility that the amount of distortion in the components is different.

It can probably be assumed that these numbers provide upper- and lower-bound estimates of the size of the distortion. Since Aubry and Nott's work examined only three institutional events, it seems reasonable to conclude that their estimate of the size of the distortion would be considered as a lower bound. Adjusted M1 can be considered as an upper bound because all possible sources of instability are attributed to distortions in M1. Hence, it can be argued that our approach might provide too much of a correction, as the methodology may also be attributing structural changes in the economic relationship between M1 and output and inflation to distortions in M1 related to financial innovations.

The alternative measures of money M1+ (M1+ is M1 plus chequable notice deposits) and M1++ were also tried as the money variable in VECMs, but a stable money-demand function could not be estimated using either definition. This result probably reflects the fact that neither M1+ nor M1++ adequately measures transactions money over history. To address this, "extended M1+" and "extended M1++" series were constructed using the level of M1 up to 1990 and then using the growth rate of M1+ (or M1++) to calculate the level of "extended M1+" (or "extended M1++") post-1990. However, even the extended definitions did not lead to a stable money-demand function, probably because the added components are not completely transactions-oriented, but also include some money held as a liquid store of value.

Since the weights on the components of adjusted M1 have changed because of financial innovations that occurred over time and not within a single quarter, assuming fixed weights on the components could be problematic. A time-varying parameter model with Kalman filtering may seem appropriate, but estimating such a model has proven difficult given the small data sample available. The results are quite sensitive to the initial assumptions, and we do not have a ready technique to restrict the weights to be positive in this environment. As a compromise, the single break in the weights is allowed.

To sum up, adjusted M1 can be thought of as the money growth that should have been observed over the last few years if the relationship between money, output, interest rates, and prices had remained unchanged from the past. Of the three possible reasons for the observed instability in money's relationship with other economic variables in the 1990s, the first reason has to do with institutional changes and difficulties with our current data-reporting system that imply we may no longer be measuring the appropriate data. The second reason has to do with the changing nature of money demand in an electronic world. Finally, the instability may reflect the economy's structural changes that are not specifically related to financial innovations. The M1 distortion estimated using the VECM incorporates all of these elements, so even though adjusted M1 can be related to a measure of transactions money, one should be careful about making inferences based on this aggregate. In fact, we consider adjusted M1 to be an interim step on the path to finding a new narrow aggregate. However, given that some economic interpretation can be put on the components of adjusted M1 and its relation to distortion-free M1, adjusted M1 is, by design, the best aggregate now available for use in the VECM.

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[15] See Bank of Canada (1998), Atta-Mensah and Nott (1999), and Aubry and Nott (2000).

4 Identifying Policy Shocks

Another change from the original VECM Hendry described is that policy shocks have now been identified in our model as the structural shocks to the interest rate equation as derived from a Choleski decomposition.[16] That is, policy shocks are identified as unanticipated innovations to the overnight interest rate.

Previously the models were generating a "price puzzle," in that a policy-induced increase in the nominal interest rate was accompanied by a rise in inflation. The puzzle arose because an increase in the interest rate caused a decline in the estimated long-run demand for money, and the decreased demand in turn created a positive money gap that led to a persistent inflation bubble. One possible explanation for this outcome is that changes in the interest rate have been more closely correlated over history with changes in expected inflation rather than with monetary policy shocks, and the model has not yet properly identified all of the movements in expected inflation. However, it seems reasonable that long-run money demand should be based on a smoother measure of the opportunity cost of money. It is unlikely that the long-run demand for money will move substantially with every transitory change in the interest rate. Consequently, an "unanticipated policy-free" interest rate series was computed by removing the model's estimated structural policy shocks from the overnight rate, basing its removal on the argument that agents would not immediately

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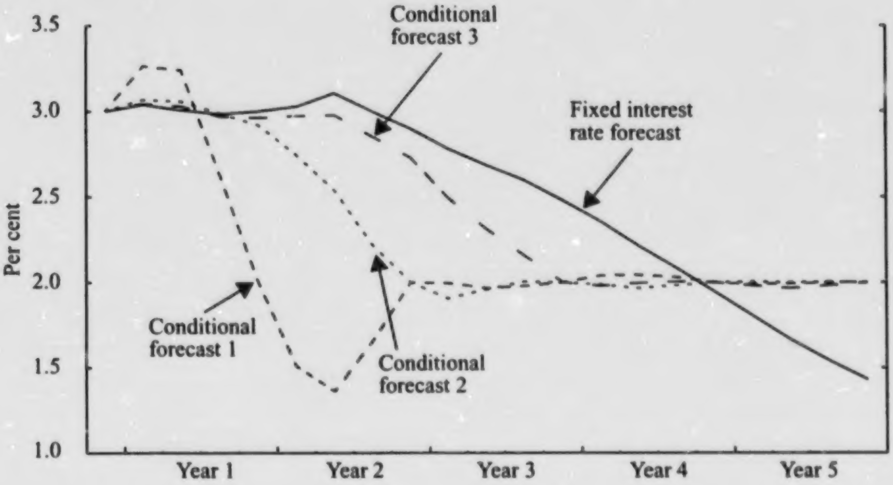
[16] The ordering of the variables in the decomposition is: U.S. interest rate, U.S. prices, overnight rate, adjusted M1, non-personal chequable accounts, output, prices, and the exchange rate.

Figure 6
Inflation forecasts



adjust their long-run money demand to the latest interest rate policy shock. In a world with limited information regarding policy shocks, agents would respond slowly to policy innovations as they learned about the nature of the latest change in interest rates. It is this unanticipated policy-free rate that enters into the calculation of the long-run money-demand parameters and the money gap.

Using our unanticipated policy-free interest rate implies that a policy tightening will leave money demand unchanged in the quarter of the shock, thereby removing the price puzzle from the model. As well, in the first few quarters following the monetary policy tightening, the interest rate increase slows money growth by more than money demand, causing an excess demand for money, and that in turn causes inflation to fall.

The Bank is also continuing to investigate how best to measure the output and interest rate variables used in calculating money demand. Empirically the money gap that is calculated from current values of output and interest rates is the best predictor of inflation. Theoretically, however, long-run money demand calculated from long-run measures of output and interest rates—for instance, potential output and equilibrium interest rates—makes more sense (see Gerlach and Svensson 1999). We hope to examine these issues in future work.

With policy shocks as they are now identified in our model, it is possible to back out the shocks to interest rates that will move inflation to

Figure 7
Money-growth forecasts

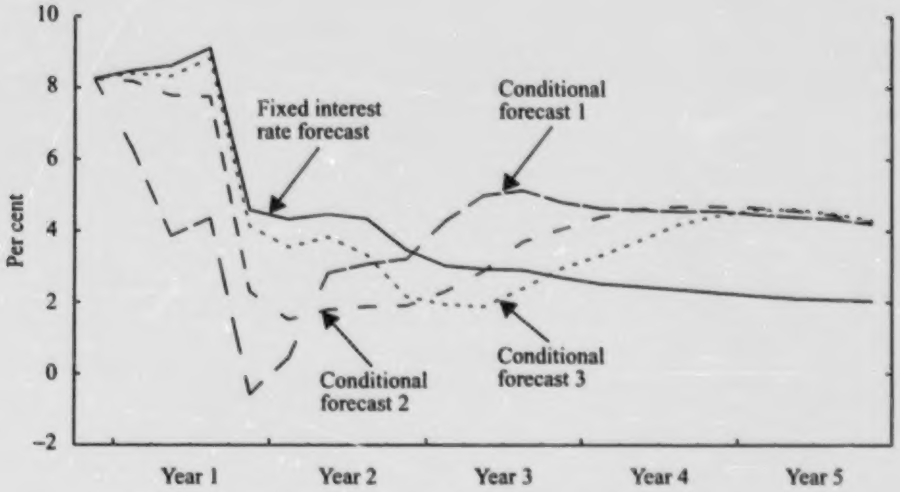
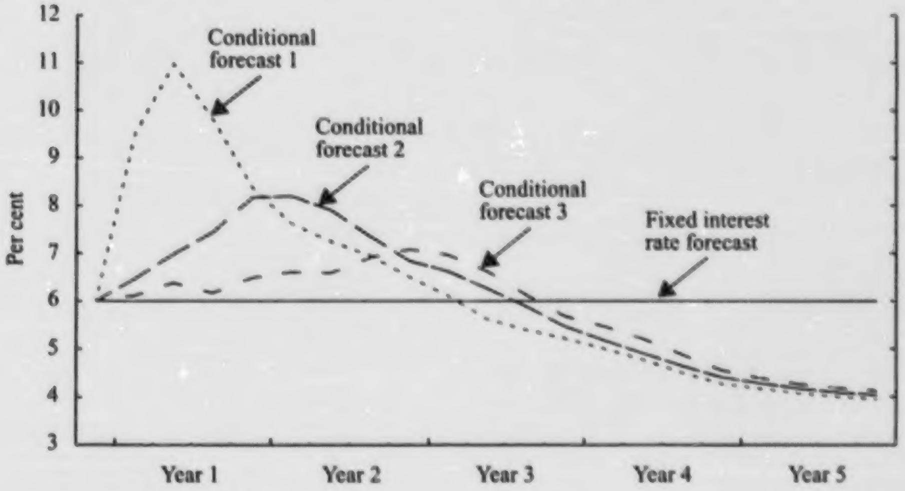


Figure 8
Overnight interest rate forecasts



the midpoint of the Bank's inflation-control target range over a given horizon.

5 Using the Adjusted-M1 VECM for Forecasting

As an example of how the adjusted-M1 VECM could be a useful model for policy-makers, assume a set of initial conditions with 3 per cent inflation, 8 per cent money growth, 3.5 per cent output growth, and 6 per cent interest rates. These conditions were also chosen so that when the interest rate was held fixed at 6 per cent, the inflation rate would be stable around 3 per cent for the first two years out of sample.

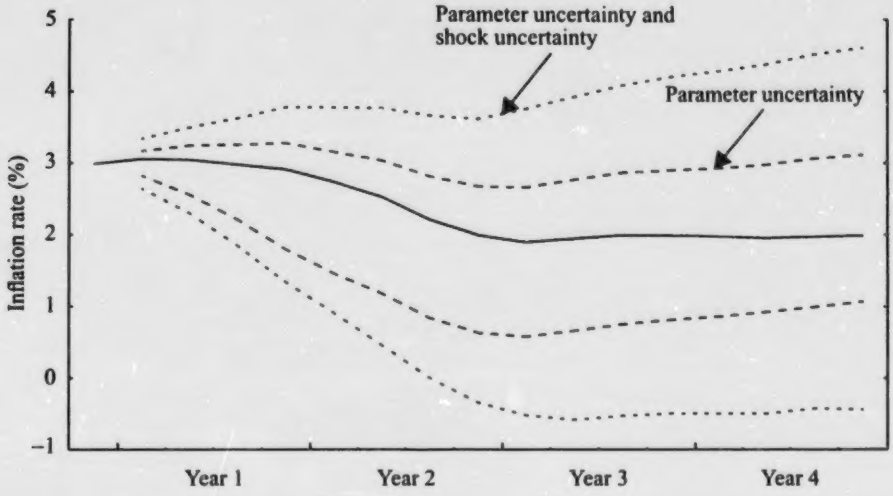
Four separate forecasts could be provided with this model given these initial conditions. The first is a fixed interest rate forecast. The other three are conditional forecasts in which we estimated the series of interest rate shocks necessary to move the 4-quarter inflation rate to the midpoint of the inflation-control target range over 4, 8, or 12 quarters, and maintain inflation at 2 per cent in the fourth quarter of each year thereafter.

Figure 6 illustrates these forecasts. In the base case, in which the overnight rate is held fixed at 6 per cent (which is above the model's steady-state value for the overnight rate), inflation will eventually decline to a point below 2 per cent in year 4. Because the overnight rate is fixed above its steady-state value, the inflation rate will converge to some new lower steady state. The line representing conditional forecast 1 shows the forecast in which the overnight rate is increased to move inflation back to 2 per cent in only 4 quarters, and the line representing conditional forecast 2 shows the forecast in which the overnight rate is increased to return inflation to 2 per cent in 8 quarters. Conditional forecast 3 moves the overnight rate to bring inflation back to 2 per cent in 12 quarters.

Figure 7 shows the money-growth forecasts associated with the inflation forecasts shown in Figure 6. In the fixed interest rate forecast, money growth is initially higher than in the forecasts in which inflation is lowered to 2 per cent more quickly. Money growth subsequently falls in the base case because the overnight interest rate is held fixed at a contractionary level above steady state.

Figure 8 plots the path of the overnight rate for the same set of forecasts. Moving inflation to 2 per cent in this example requires tightening policy through an increase in the overnight rate. However, by year 3 the policy tightening is completely reversed to keep inflation from falling below 2 per cent. The closer the target horizon (4 quarters in conditional forecast 1, but 12 quarters in conditional forecast 3), the more the interest rate must be increased to achieve the target. Similarly, money growth is more volatile for

Figure 9
Conditional inflation forecast 2 with error bands



closer target horizons. Choosing the appropriate policy requires considering both the target horizon and the required interest rate or money-growth movements.

Another way of conveying information about the state of the world and possible future outcomes is to provide confidence intervals or probabilities of these outcomes. For instance, a "reference range" or "monitoring range" can be constructed for money growth that is consistent with achieving 2 per cent inflation over a given horizon. This reference range would have some associated probability of inflation remaining within the target range or, alternatively, some tighter bands. As actual money growth becomes known, deviations of growth from the range should then give early warning of any impending deviations of inflation from the target range. One advantage of using a money-growth reference range as an information variable, in addition to the inflation forecasts themselves, is that it helps to gauge the change in inflationary pressures in the months since the reference range was derived.[17] Gerlach and Svensson (1999) found that the information from a money-growth indicator is subsumed by a money gap.

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[17] The main distinction between an intermediate target and an information variable lies in the degree of correlation between the intermediate target/information variable and the goal variable (GV). An intermediate target (IT) is assumed to have a tight correlation with the GV, whereas the correlation of an information variable with the GV is much looser. A related concern is the degree of controllability between the IT and the GV. If policy-makers are unable to control the IT, it seems unlikely that they would be able to control the GV.

Figure 10
Distribution of the 4-quarter conditional inflation rate forecasts based on parameter uncertainty for conditional forecast 2

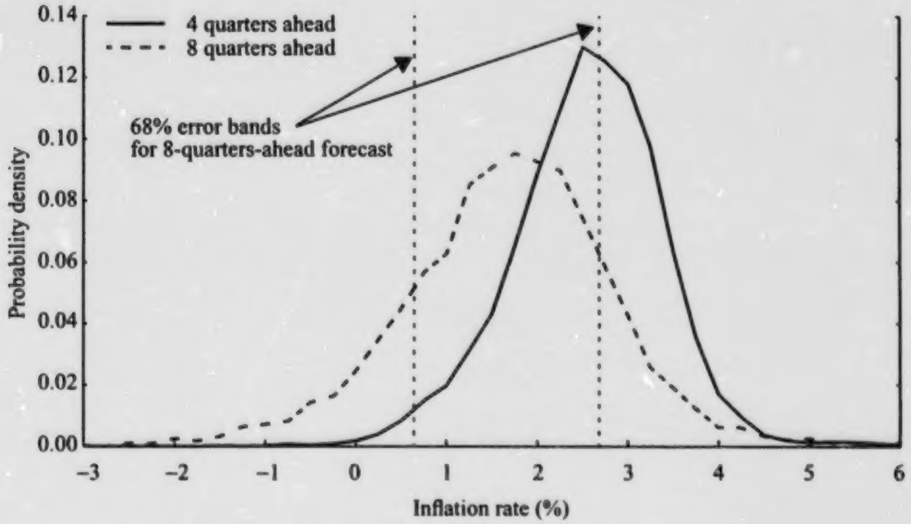

Figure 11
Distribution of the 4-quarter conditional inflation rate forecasts based on parameter and future shock uncertainty for conditional forecast 2

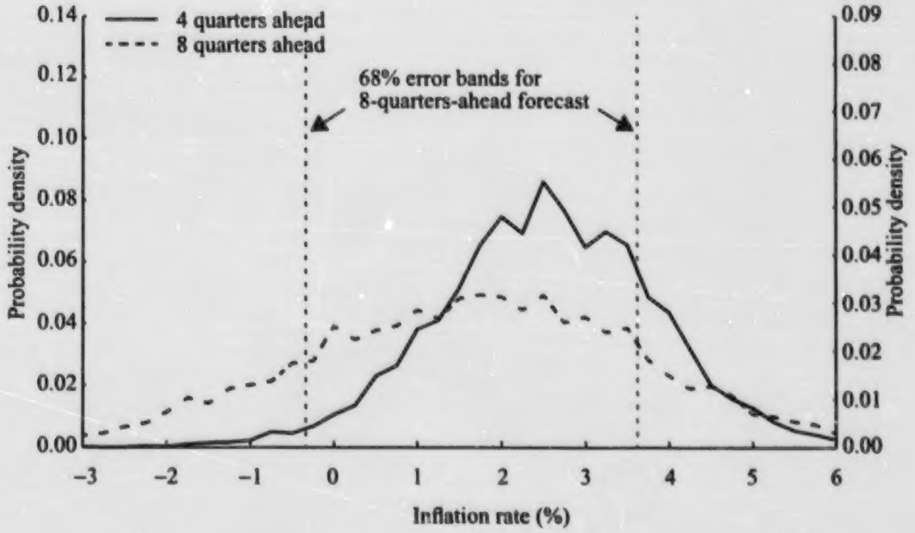

Table 1
Inflation probabilities from conditional forecast 2 with parameter and future shock uncertainty

Date	Probability of inflation between 1 and 3 per cent	Probability of inflation between 1.5 and 2.5 per cent
Year 1Q1	50%	8%
Year 1Q2	55%	24%
Year 1Q3	58%	30%
Year 1Q4	52%	27%
Year 2Q4	37%	19%
Year 3Q4	32%	17%

Our findings generally support this claim. However, an attraction of money growth rate indicators and reference ranges is that they are perhaps easier to explain than a money gap and thus may help a central bank explain its reasons for a policy action.

The European Central Bank (ECB) uses the 3-month growth rate of the 12-month moving average of M3 growth as one of the pillars of its two-pillar strategy of achieving and maintaining price stability.[18] Although the ECB uses a broad aggregate to allow for the possibility of shifts such as those due to financial innovations, we have explicitly accounted for the shifts that have occurred in Canada in our narrow aggregate.

Alternatively, the probabilities of inflation remaining within the target range can be calculated without using a reference range for money growth. Figure 9 shows the conditional inflation forecast and two possible 68 per cent confidence intervals (about 1 standard deviation) when the interest rate is set as in conditional forecast 2 to achieve 2 per cent inflation in eight quarters. The confidence intervals were calculated from a bias-corrected bootstrap technique proposed by Kilian (1998) and discussed in Sims and Zha (1995).[19] The distribution of inflation forecasts shown by the inner bands is based on uncertainty about the model's parameters. The distribution shown by the outer bands is based on uncertainty about both the model's parameters and possible future exogenous shocks.

The complete distributions for the 4-quarter inflation forecast four and eight quarters ahead are plotted in Figures 10 and 11. The vertical lines

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[18] The ECB's stability-oriented monetary policy is based on: (i) a prominent role for money and (ii) a broadly based assessment, using financial and other indicators, of both the outlook for price developments and the risks to price stability.

[19] This technique requires one bootstrap to first obtain an estimate of the bias in the model's coefficients. Bias-corrected coefficients are calculated and used for a second bootstrap simulation to generate the error bands. We computed 5,000 bootstrap samples at each stage.

Figure 12
Inflation forecasts under alternative decompositions

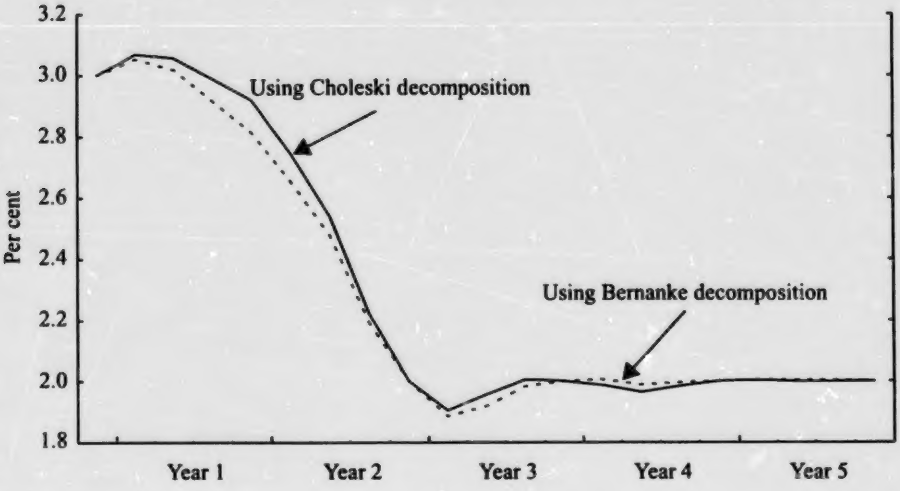


Figure 13
Money-growth forecasts under alternative decompositions

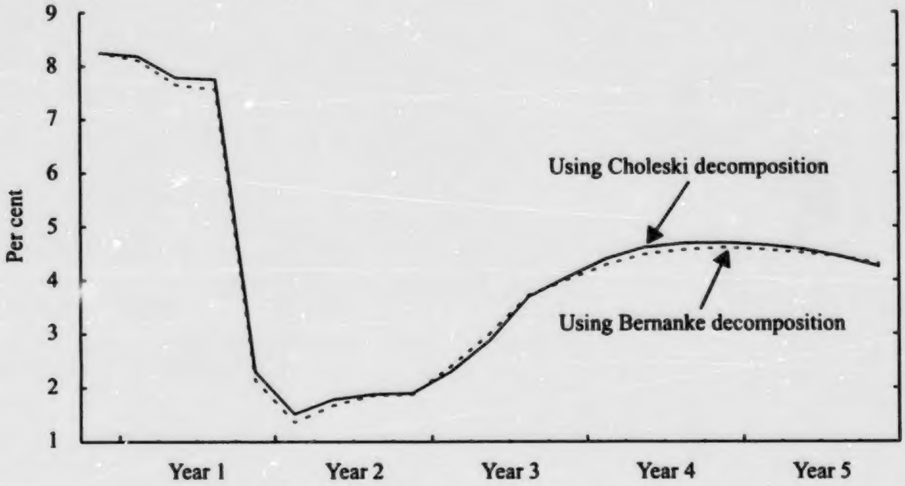
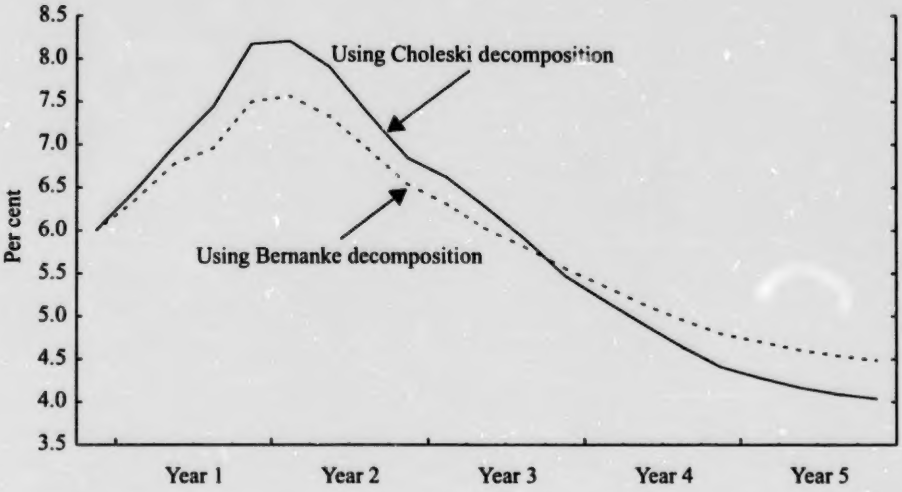


Figure 14
Overnight rate forecasts under alternative decompositions



represent the 68 per cent error bands for the 8-quarters-ahead forecast as shown at the end of year 2 in Figure 9. From distributions such as these we can calculate various probabilities that may interest policy-makers. The probabilities that inflation will be within the 1 to 3 per cent official inflation-control target range or within a tighter range of 1.5 per cent to 2.5 per cent are given in Table 1. Similar distribution functions can be computed for each of the forecast variables. For instance, monitoring ranges for the money-growth rate or the interest rate can be computed that are consistent with achieving the target inflation rate.

In summary, our model can generate the point forecasts and their associated probabilities for any number of starting-point assumptions and/or policy scenarios, providing significant information about possible outcomes and desirable policy scenarios.

6 Future Work

Decompositions other than the Choleski could have been used to identify monetary policy shocks. The estimate of the response of money growth to an interest rate shock has varied over time, and thus it may be appropriate to include an overidentifying restriction in the decomposition of shocks (cf. Bernanke 1986 or Sims 1986). Such a restriction would change the contemporaneous response of money growth to a variation in interest rates from the average response estimated over history with the Choleski decomposition. When one examines recent data, money's response to an interest rate shock appears to have increased. (The greater contemporaneous response of money growth to movements in interest rates might be explained by a change in how rapidly banks respond to policy-induced shocks to interest rates to alter the amount of liquidity they provide to agents in the economy.) The average historical change in money growth for a 100-basis-point change in the overnight rate has been about 0.6 per cent. Using a Bernanke decomposition in another version of the model used below, this response has been increased to 1 per cent.[20]

For the conditional forecast in which policy responds to push inflation to 2 per cent in eight quarters (conditional forecast 2), the inflation and money-growth rates are essentially the same using either the Bernanke or Choleski decomposition (see Figures 12 and 13). However, the size of the interest rate decrease needed is smaller in the Bernanke case than in the Choleski case (see Figure 14). Money growth does relatively more to move inflation towards its target, leaving less work to be done via the interest rate channel.

Our future research will also examine more-sophisticated alternative monetary policy identification techniques, such as those employed for Canada by Fung and Kasumovich (1998) and Fung and Yuan (2000). Varying this aspect of the model will perform a robustness check of its predictions. The Bank is also investigating definitions of transactions money as well as the identification of desired money supply for financial institutions.

Conclusion

The M1 VECM has predicted inflation reasonably well over history and still appears to be a good forecasting model, especially in light of modifications like using adjusted M1, identifying policy shocks, and deriving probabilities for inflation outcomes.

Forecasts from the VECM can augment the information coming from other models used at the Bank. They can provide alternative views of what could happen in the economy and give some information about the "balance of risks." Multiple models could be especially helpful to policy-makers during times of extreme uncertainty and/or structural shifts, but even in relatively stable times, advice from different models helps to balance risks about the outlook for the future.[21]

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[20] The 1 per cent estimate of the contemporaneous response of money to a 100-basis-point change in the overnight rate is within 2 standard deviations of the estimate of the money-response parameter.

Different models that yield similar predictions would tend to lessen policy-makers' uncertainty regarding possible outcomes, *ceteris paribus*, making policy judgments somewhat easier. However, relying on multiple models has the greatest value when a model relying on one set of variables and assumptions forecasts one outcome and another model with a different set of variables and assumptions forecasts another—perhaps quite different—outcome. In any event, advice based on multiple models should give policy-makers more information and hence allow them to achieve their desired goals. As Alan Blinder (1998, 12) advises, "Use a wide variety of models and don't ever trust any one of them too much."

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21. See, for example, Engert and Selody (1998) and Berk (1997). Different models are used to entertain a possible shock, such as a change in policy or a real-side shock, and evaluate its impact on the forecasts of relevant variables. Such an approach may also help in assessing the uncertainty associated with particular shocks.

Appendix
Details of the Adjusted-M1 VECM

Step 1: Estimating long-run money demand and the money gap

The Johansen-Juselius methodology is used to test for the existence of a unique long-run cointegrating relationship between money, inflation, output, and interest rates (non-seasonally adjusted data). The model is an error-correction model because deviations of money demanded from money supplied (the money gap) are assumed to be corrected in the long run. The model has the form

$$\Delta X_t = \Gamma(L)\Delta X_t + DZ_t + \alpha\beta'[X_{t-1}, D80a_{t-1}], \tag{A1}$$

where

$X_t = [M1_t, CPI_t, Y_t, RONf_t]$

$RONf_t$ = level of "policy-free" overnight interest rate $= RON_t - \varepsilon_t$

ε_t is the residual from the interest rate equation (A8)

$M1_t$ = log level of adjusted M1

Y_t = log level of real output

CPI_t = log level of the consumer price index

Z_t = [constant, 3 seasonal dummies, output gap$_{t-1}$, Δ log(exchange rate) from t to t–3, $\Delta USCP90_t$ rate, $D80b^* \Delta NPN_t$, $D80a_t$]

output gap$_{t-1}$ = Y_t – Bank of Canada's estimate of potential output from QPM

$USCP90$ = U.S. 90-day commercial paper rate

$D80b$ = 0 for 1979Q4 and before, and 1 thereafter

NPN_t = non-personal notice deposits

$D80a_t$ = 0 for 1979Q4 and before, and 1 for 1983Q1 and after. Increases linearly from 0 to 1 from 1980Q1 to 1982Q4.

$\Gamma(L)$ = matrix of parameters for a fourth-order lag process

Equation (A1) is estimated from 1956Q1 to 1998Q4.

The money gap is calculated as

$$mgap_t = c + M1_t - CPI_t - \hat{\beta}_{yt} Y_t + \hat{\beta}_{rt} RONf_t + \hat{\beta}_{d81t} D80a_t, \qquad \text{(A2)}$$

where

c = long-run constant to ensure the gap converges to 0 in steady state

$\hat{\beta}_{yt}, \hat{\beta}_{rt}, \hat{\beta}_{d81t}$ = Johansen estimates of the long-run parameters

Some additional variables need to be calculated before step 3, the forecasting step.

Step 2: The interest rate gap

The interest rate gap, $RGAP_t$, is estimated from the auxiliary equation

$$R_t = k + aUSR_t, \qquad \text{(A3)}$$

where

$R_t = RON_t$ – expected inflation$_t$

$USR_t = USCP90_t$ – expected U.S. inflation$_t$

Expected, $E[inflation_t]$ = actual inflation from t–1 to t

Expected U.S. inflation$_t$ = actual U.S. inflation from t–1 to t

Therefore the real interest rate gap is $R_t - (k + aUSR_t)$. To obtain a nominal interest rate gap, an expected-inflation gap is added. The resulting nominal interest rate gap is

$$RGAP_t = R_t - (k + aUSR_t) + E[inflation_t] - inflation_{ss}, \qquad \text{(A4)}$$

where expected inflation is defined as above, and steady-state inflation is assumed to be the average inflation rate for the previous 10 years. In 1993Q1 the steady-state inflation rate shifts to 2 per cent and stays at that level.

Step 3: The forecasting model

Equation 1: M1

$$\Delta M1_t = \Gamma_1(L)\begin{bmatrix}\Delta M1_t\\ \Delta CPI_t\\ \Delta Y_t\\ \Delta RON_t\end{bmatrix} + D_1 Z_t + \alpha_1 MGAP_{t-1}, \tag{A5}$$

where

Z_t = [constant, output gap$_{t-1}$, Δ log(exchange rate) from t to $t-3$, $\Delta\, USCP90_t$ rate, $D80b^{*}\Delta NPN_t$, $MONPOL_{t-1}$]

$MONPOL_{t-1}$ = 0 for 1987Q4 and before, the 4-quarter inflation rate less target inflation thereafter. Target inflation is 3 per cent from 1988Q1 to 1992Q4, then declines to 2 per cent in 1995Q4 and stays at that level.

$MGAP_{t-1}$ = the money gap derived above in step 1

Equation 2: Price

$$\Delta CPI_t = \Gamma_2(L)\begin{bmatrix}\Delta M1_t\\ \Delta CPI_t\\ \Delta Y_t\\ \Delta RON_t\end{bmatrix} + D_1 Z_t + \alpha_1 MGAP_{t-1}, \tag{A6}$$

where

Z_t = [constant, output gap$_{t-1}$, Δ log(exchange rate) from t to $t-3$, $\Delta\, USCP90_t$ rate, $D80b^{*}\Delta NPN_t$, $D80a$, $DPOLICY$]

$DPOLICY$ = 0 for 1992Q4 and before, increases to 1 in 1999Q4 and after

$MGAP_{t-1}$ = the money gap derived in step 1

The *DPOLICY* shift dummy is introduced as a permanent shift dummy in this price equation to represent a shift to a new lower steady-state inflation rate. The equation is restricted in such a manner that it yields a steady-state inflation rate of 2 per cent.

Equation 3: Output

$$\Delta Y_t = \Gamma_3(L)\begin{bmatrix}\Delta M1_t - \Delta CPI_t \\ \Delta Y_t \\ spread_t\end{bmatrix} + D_1 Z_t + \alpha_1 MGAP_{t-1}, \tag{A7}$$

where

$spread_t$ = overnight rate – 10-year-and-over bond rate from QPM

Z_t = [constant, output gap_{t-1}, $\Delta USCP90_t$ rate, $D80b^*\Delta NPN_t$, $D91$, $D89$]

$D91$ = 0 for 1990Q4 and before and 1 thereafter

$D89$ = 0 prior to 1989Q1, 1 between 1989Q1 and 1996Q2, and 0 thereafter

The equation was restricted so that the steady-state output growth rate is 2.3 per cent and so that the coefficients on prices have the opposite sign but same magnitude as those on money (real money growth, rather than nominal money growth is used in the equation).

Equation 4: The overnight rate

$$\begin{aligned}\Delta RON_t = {} & \Gamma_4(L)\left[\Delta M1_t\ \Delta CPI_t\ \Delta Y_t\ \Delta RON_t\right] + D_2 Z_t \\ & + \alpha_2 MGAP_{t-1} + \gamma_1 RGAP_{t-1} + \gamma_2 UIP_{t-1},\end{aligned} \tag{A8}$$

where

Z_t = [constant, output gap_{t-1}, Δ log(exchange rate) at t, $\Delta USCP90_t$ rate from t to $t-3$, $D80b^*\Delta NPN_t$, $MONPOL_{t-1}$]

$RGAP_{t-1}$ = the interest rate gap derived above in step 2

UIP_{t-1} = deviation from uncovered interest rate parity when UIP is defined as

$$\begin{aligned}UIP_t = {} & RON_t - (uscp90_t + 400(lforex_{t+1} - lforex_t) \\ & + k + (a-1)USR_t),\end{aligned} \tag{A9}$$

where a and k are from equation (A4) above and

$lforex$ = log level of Can\$/US\$ exchange rate

Equation 5: Relative purchasing power parity

$$RPPP_t = \Gamma_3(L)\left[\Delta M1_t\ \Delta Y_t\ \Delta RON_t\ RPPP_t\right] + D_2Z_t + \gamma_2 RGAP_{t-1}, \tag{A10}$$

where

$RPPP_t = \Delta SPOT - \Delta CPI + \Delta USCPI$

Z_t = [constant, output gap_{t-1}, $\Delta USCP90_t$ rate from t to $t-2$, $D60Q1$, $D73{*}RPPP_{t-1,}$ Δ lpcom from t to $t-2$]

$D60(Q1)$ = one-period dummy with a value of 1 in 1960Q1

$D73$ = a permanent shift dummy with a value of 1 from 1973Q1 and 0 before

lpcom = log level of commodity prices

$SPOT$ = log level of spot Can$/US$ exchange rate

Equation 6: The change in non-personal notice deposits

An AR(4) with constant shift dummies $D80a$, $D87Q3$, where

$D87Q3$ = 1 from 1987Q3 and 0 before.

Equation 7: The U.S. inflation rate

An unrestricted AR(4) on the quarter-over-quarter U.S. inflation rate.

Equation 8: The U.S. 90-day real rate

An AR(2) on the U.S. 90-day real rate with constant shift dummies for 1973Q1 to 1979Q4 and 1981Q1 to 1986Q1.

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Discussion

Stefan Gerlach

Overview

The Adam and Hendry paper estimates a simple but attractive VECM on Canadian data, incorporating M1 and the consumer price index as the key variables. Their paper is motivated by the fact that while in the past a tight and stable relationship existed between these variables, it broke down in the early 1990s. Adam and Hendry argue that there are three possible causes for this: the "restructuring" of the Canadian economy, the introduction of inflation targeting, and financial innovation that drove a wedge between the economically relevant measure of narrow money and M1. They focus on the third explanation and propose a strategy to adjust M1 to overcome the "distortions" in this aggregate. Moreover, they demonstrate that when the new data are used, the estimated model is well-behaved over the entire sample period. Finally, they show how the model can be used to forecast inflation and for policy analysis and simulation.

My first reaction to their paper was very positive. Inflation is a monetary phenomenon, and episodes of even moderate inflation are not possible without sustained growth of the monetary aggregates. Moreover, while movements in money are largely endogenous reactions to the state of the economy, it is difficult to believe that money does not also play an active role in the transmission mechanism. Thus, in my view, money is important, and we should have the good sense to use this fact when conducting policy.

Of course, the fact that money growth causes inflation and the likelihood that money at least partially plays an active role in the transmission mechanism do not necessarily imply that money should be targeted or be *primus inter pares* among indicator variables. The weight that should be attached to money is squarely an empirical question, and it is precisely the type of elegant econometric research Adam and Hendry conduct that may be useful in settling it.

However, in reading their paper I must admit that I was less persuaded of the usefulness of looking hard at money when conducting policy in Canada than they appear to be. Rather than focusing my discussion on narrow, econometric issues—such as whether it makes sense to treat the output gap and the exchange rate as exogenous variables in the cointegration analysis, given that the levels of output and interest rates are taken to be endogenous—I will raise some more-general issues that the paper suggests.

Issue 1: Data Adjustments and Dummies

As Adam and Hendry note, the earlier stable linkage between M1 and inflation seemed to disappear in the 1990s. In order to get the data to speak, they construct an adjusted measure of M1 and show that the model also behaves well in the 1990s if the adjusted data are used. This research strategy warrants several comments.

First, the way in which the adjusted data are computed necessarily implies that the model will fit them well. To adjust the data, Adam and Hendry estimate the VECM on data before the break. They then construct out-of-sample predictions of M1 under the assumption that no break occurred and view the predicted level of the money stock as measuring adjusted M1.[1] To quote them (page 162), "adjusted M1 can be thought of as the money growth that should have been observed . . . if the relationship between money . . . and prices had remained unchanged." In a sense the model fits the adjusted data because it has been used to construct those very data. The circularity of this approach not only suggests that the new data do not add much, if any, information, but also that the full-sample estimates of the VECM are subject to generated regressors bias of unknown importance.

Second, whether the adjustment of the data and the use of structural-break dummies are sensible depends on what the model is to be used for. If the purpose is to interpret historical data, then this approach is eminently reasonable. For instance, Adam and Hendry show that when the adjusted data are used, the estimated income elasticity of money demand is stable over time and almost exactly 0.5, as suggested by Baumol and Tobin's justly famous square-root formula of money demand.

However, if the model is to be used for policy analysis, accepting the data adjustments and the inclusion of structural-break dummies is more difficult. In fact, central banks hesitate to rely on money when conducting policy precisely because such adjustments and dummy variables are typically necessary to interpret monetary data. To put this differently, although Adam and Hendry's model does a good job in predicting inflation, in order to use it for policy purposes, one must also forecast the need for future data adjustments and additional break dummies, both of which are hidden but integral parts of the model. A particular concern is that structural breaks are not always immediately obvious. In their paper, for instance, Adam and Hendry take care to adjust M1 for shifts that occurred some seven years before writing.

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[1] Strictly speaking, they regress the forecast values on some other variables and use the fitted regression to construct the adjusted-M1 data.

Issue 2: Is This Model Better than Alternative Models?

Adam and Hendry demonstrate that the VECM can be used to forecast inflation and to determine the appropriate path for short-term interest rates given a desired path for inflation. Of course, while this model may be useful for these purposes, that does not imply that it is the best model. There might be better non-monetary models that can be used for the same purposes. In reading their paper one therefore naturally wonders how well the model compares with alternative forecasting models, of which there ought to be a fair number available for Canada. In my view, Adam and Hendry would be more persuasive if they had demonstrated that their model indeed provides more accurate inflation forecasts than the competition does. Since we care about money because we care about inflation, a natural starting point would be to look at single-equation models of the inflation process. Encompassing tests could then be used to explore the different models' performance.

Issue 3: What Is the Role of Inflation Targeting?

Adam and Hendry recognize that the source of the structural break in the relationship between money and prices need not be financial innovations' influence on M1, but could be developments elsewhere in the economy. They explicitly mention that the shift of the relationship could be due to the adoption of inflation targeting in the early 1990s coincident with the structural break they emphasize. Given that the introduction of inflation targeting was arguably one of the most important developments in modern Canadian monetary history, one that is eminently likely to have affected the price-setting process, it is somewhat puzzling that the authors choose instead to focus the analysis solely on the possibility of a distortion of the M1 data.

To see why inflation targeting might have caused the observed shift in the econometric relationship, consider an economy with a history of low to moderate inflation and with a not fully credible central bank. In such an economy it seems plausible that agents will interpret an increase of money growth as a signal that inflation is about to increase. With rising inflationary expectations influencing wage- and price-setting decisions, it is likely that money growth and actual inflation will be closely associated. Next, introduce an inflation target and suppose that it is perfectly credible, so that the expected rate of inflation is equal to the inflation target. Under these conditions an increase in money growth will have no impact on inflationary expectations and therefore little impact on actual inflation. Thus, inflation targeting may well break the link between money and inflation.

Investigating this issue would necessitate looking more closely at the stability of the individual equations in the VECM, in particular the equation for inflation. Indeed, it would be desirable to introduce a more structural inflation equation that allows for the impact of inflation targeting on inflationary expectations and price setting. Given the high-quality econometric work Adam and Hendry have already done, this extension would seem small.

Discussion

Shamik Dhar

Introduction

Let me start by saying that I like Adam and Hendry's paper and, indeed, the theme of the whole conference. I have a few quibbles about technicalities that I'll detail in a second, but the overall theme is one I concur with—that applied models of this type, in which money plays an active and central role in the transmission mechanism, should be part of every central bank's tool kit. The commitment to a tool kit—a range of models with which to analyze the economy and specific policy questions—is itself very important and is referred to many times in their paper. We at the Bank of England have recently published a book describing the suite of models available to us (Bank of England 1999).

Why Monetary Models?

In recent years a "consensus" model appears to be arising in the monetary policy literature—call it IS-LM with microfoundations (of a sort). The seminal works are those of Rotemberg and Woodford (1997) and McCallum and Nelson (1998), and these consensus models have proved very useful in many circumstances, for instance in the policy-rules literature. However, central bankers might be surprised to hear that money plays no role in these models; instead, inflation is anchored through a perfectly credible inflation target. Nor is there a role for money in the transmission mechanism of these models, whereas Professor Meltzer of Carnegie Mellon University has recently documented a strong relationship between real activity and lagged real money balances, and Edward Nelson, in internal work at the Bank of England, has found a similar relationship for the U.K. I like to think this conference is addressing the concerns some of us have about this state of affairs. Money may have a role as an indicator in the short run, it might play a role in the transmission mechanism (as the Adam-Hendry paper also seems to suggest), and in some cases it might even help anchor long-run inflation expectations. All these possibilities are explored in different papers at this conference and will remain of interest to monetary economists, even in inflation-targeting central banks.

The Adam and Hendry Model

The authors estimate a VECM using techniques popularized by Johansen and Hendry amongst others. Adam and Hendry identify a standard money-demand function—a relatively narrow real money aggregate (M1) is modelled as a function of income and an interest rate. I would have liked to see some more of the equations as well as key test statistics. I generally struggle with papers that contain reams of equation printout, but their paper goes a little too far in the opposite direction. A few questions immediately spring to mind from the description contained in their section 2.

- First: Adam and Hendry have chosen to model the upward trend in M1 velocity in the output coefficient rather than, say, impose a unit coefficient and run a velocity equation on a deterministic or stochastic trend of some sort. I have no firm views about which of these techniques is preferable, but the sample period is one in which rapid technological progress in payments systems is very important. Certainly in the U.K. and the United States there are signs that narrow money velocity has flattened off and may even be starting to fall now. At the very least it would be nice to see some recursive estimates of this output coefficient and, in the conditional-forecasting context, some means by which any changes in trend velocity could be easily accommodated.
- Second: Why is the interest rate term a level rather than a spread over some market rate? I understand that adjusted M1 includes interest-bearing deposits and that much of this work is motivated with reference to buffer-stock theories of money. I'd have thought both these factors would have argued for a spread term (which they already have in the underlying vector autoregression [VAR]) and would introduce an extra channel (the "spread channel") through which monetary policy operates. I guess Adam and Hendry would argue that the constructed aggregate they use ought to be a measure of transactions money, not savings money, but I need a bit more convincing.
- Third: A number of (I presume) weakly exogenous variables are included to induce VECM stability. These variables include a lag of the output gap and the change in non-personal notice deposits. I am concerned about the number and variety of variables required to induce stability ex post and

also about their role in ex ante forecasting. My question about the output gap is: How is the gap projected when we come to conditional forecasting? Is its projection consistent with the output projections coming from the output equations? If not, is this a problem? Concern with the change in non-personal notice deposits is linked to the velocity question: How do you project non-personal notice deposits in a period of rapid velocity change and make it consistent with the underlying trend velocity assumption?

Having estimated a long-run money-demand function, Adam and Hendry then construct an aggregate money gap, shown in their Figure 1. We have produced similar charts in the U.K. using similar techniques, and they look very like this one. I'm encouraged by this—and concerned at the same time. Your eye is immediately drawn to the great inflation (as Larry Christiano calls it) of the 1970s, which appears to be at least in part a global shock. The correlation and leading-indicator properties were great then, but our practical problem in selling money-based forecasts in the 1990s (certainly to the Monetary Policy Committee at the Bank of England) is that correlation and leading-indicator properties are not so great now. Something happened to inflation expectations in the 1990s, and monetary growth or gaps struggle to explain what that was. Monetarists can take some comfort from the fact that "output gap" models seem to do just as badly—but this is pretty cold comfort.

Adam and Hendry spend some time discussing the construction of their dependent variable money aggregate—adjusted M1, which they describe as "distortion-free" money but which I prefer to think of as "transactions money." This is essentially a weighted average of various asset categories within demand and notice deposits. My only comment here is that we know in theory what the best measure of transactions money is—divisia (or household divisia). And at some future point it might be interesting to redo this work using a divisia aggregate, though I realize that's a major construction task in itself. Also, I thought I'd draw the authors' attention to some work recently done in the U.K. by Terry Mills and Leigh Drake of Loughborough University. These guys construct what they call "an empirical divisia" by looking for cointegrating relationships among the various asset categories that make up U.K. broad money. They find one and, what's more, the cointegrating coefficients (the empirical divisia weights) appear to be pretty stable over time. I prefer to call this approach a "constant-velocity M"—since that is what it is by construction—and it seems to bear some resemblance to Adam and Hendry's intentions. However, there remains a velocity trend in adjusted M1, and I'd be interested in knowing the authors' explanation for what is driving it.

Adam and Hendry identify monetary policy shocks and ingeniously rid themselves of a price puzzle doing so. But this generates another question: Rather than strip monetary surprises out of money demand, would not a better system be one in which the money supply reacted "correctly" to a monetary shock (of different types)? To plug some work of ours for a minute, in a recent paper with Ryland Thomas and Darren Pain (Dhar, Pain, and Thomas 2000), our approach has been to estimate a structural VAR in which a whole range of shocks are identified—including three types of monetary shock. These include a money-demand (or velocity) shock, an inflation-target shock, and a standard monetary policy shock. We do not find a price puzzle precisely because the shocks are identified with avoidance of that in mind. Multiple shocks are also important because, in general, the leading-indicator properties of a money gap will depend on what has caused the gap to arise in the first place. A temporary money-demand shock can have very different consequences for inflation than a temporary money-supply one, even though the money gaps might look the same in the short run. We had a concrete example of this in the U.K. when in the late 1990s we saw a large positive money gap emerge and then dissipate very quickly with no consequences for inflation. Ex post we know that this was a shock to the money demand of financial institutions in particular, but it was difficult to tell that at the time. And indeed our inflation fan chart contained an upward skew for much of 1998 due to this money gap.

Our experience raises the question of whether error-correction systems of this type really get to the heart of buffer-stock theory as its progenitors would recognize it.

How Does Buffer-Stock Money Fit In?

Slightly awkwardly, I think. Buffer-stock theories have an old and honourable tradition in monetary macros, but they sit slightly at odds with current modelling vogues and their links with the econometric methodology outlined here are not always clear. I guess I would argue for Adam and Hendry's work to be complemented by a more structural approach in which shocks and propagation mechanisms are clearly identified and not averaged out in the estimation process. You have the basis for that structural approach in Scott's other work on limited-participation models, and we are currently working on an ECM representation of the limited-participation model we have constructed at the Bank of England (Dhar and Millard 2000).

In summary, though, Charleen and Scott have, in a nice paper, identified that money plays a role in transmitting monetary policy in Canada, and that, I hope, could convince monetary economists here and in other central banks to occasionally put money back into the models they commonly play with.

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General Discussion

Adam and Hendry responded to a number of points the discussants raised. Regarding Stefan Gerlach's comments, first they noted that the forecasts from the M1 VECM need to be taken with a grain of salt, which is why they provide confidence bands around all the forecasts. They also acknowledged that their forecasts may be open to the Lucas critique.

Second, the M1 VECM forecasts have been compared to alternative models in an earlier paper (Engert and Hendry 1998). That paper found that the M1 VECM outperforms a simple autoregressive process and an inflation-forecasting model based on the Phillips curve. Finally, they emphasized that their adjusted M1 classifies all potential shifts of the aggregate as financial innovations. This aggregate would not be used indefinitely. For the future a divisia aggregate might eventually prove useful.

In response to Shamik Dhar's comments, Adam and Hendry noted that the own rate of return on M1 does not explain much of the shift in the aggregate. They also emphasized that the model does not depend heavily on the exogenous variables, such as the output gap, that were added to stabilize the parameters. In future work they intend to reconsider the variables that enter the money-demand relationship. For example, a short-term interest rate is currently used, but they will examine whether a longer-term rate should be used instead.

Charles Freedman observed that central bankers often rely more upon the judgment of economists monitoring current economic developments than on any single forecasting model to predict future paths of inflation and output. This limits the concrete value of ex post forecasting exercises to policy-makers.

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* Prepared by Greg Tkacz.

Frank Smets questioned the focus on the money gap when McPhail's paper found that money growth is more suitable to forecasting inflation. An advantage to focusing on the growth rate, he argued, is that it is robust to level shocks.

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Swiss Monetary Policy under a Flexible Exchange Rate Regime: Monetary Targets in Practice

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Michel Peytrignet

Introduction

Since the advent of flexible exchange rates, the Swiss National Bank (SNB) has implemented a monetary policy based largely on monetarist principles. As early as 1975 the Bank developed an intermediate monetary target designed to approach as closely as possible the ultimate goal of Swiss monetary policy—price stability. From the very beginning the SNB has been obliged to take a pragmatic approach, accepting the incontrovertible fact that Switzerland, a small open economy with a sizable financial market, is frequently buffeted by large numbers of external shocks.

I begin this study with a description of the basic theory that the SNB has always relied on in developing its monetary policy concept. I then review the major steps in Swiss monetary policy between 1975 and 1999 in order to examine event-fuelled conceptual changes over time and to indicate how, and to what extent, monetarist principles have been applied in Switzerland. My review emphasizes the positive role played by monetary aggregates in a dynamic thought process dominated by the need for flexibility to handle the various shocks the Swiss economy and the demand for money experienced. The paper ends with a summary of the key lessons to be learned from this experience.

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* I would like to thank Thomas Jordan, Georg Rich, Eveline Ruoss, and Umberto Schwarz for their comments and suggestions.

1 The Theoretical Principles underlying Swiss Monetary Policy

1.1 Fundamental principles

The SNB has adopted three key principles that can be attributed to monetarism.[1] The first of these is making price stability the ultimate aim of monetary policy. The second is accepting the postulate that inflation is an essentially monetary phenomenon. The third is taking into account the long and variable lags between monetary policy incidents and change in the economy and prices in Switzerland and elsewhere.

The first principle stems from the fact that price stability is recognized as the condition essential to sustained change in an economy moving along its potential growth path.[2] The second principle stems from the quantitative theory of trade, a theory that emphasizes the causative role of currency in a long-term inflationist process when monetary aggregate velocity is stable. Finally, the third principle stems from the fact that extended and variable lags in the impact of monetary policy on future price changes lead to significant uncertainty in understanding monetary policy transmission mechanisms, making it difficult, even impossible, to understand the exact dynamics of these mechanisms within an economy and precluding an active role for monetary policy.

Within the monetarist school the most important implication of these principles has been Milton Friedman's 1960 formal recommendation to the American central bank that it adopt a passive rule of monetary policy in the form of a monetary based growth target of 4 per cent per annum.[3]

Application of this passive rule for monetary policy should not necessarily imply that monetary conditions remain stable throughout a business cycle. Continuous growth of the money supply at a fixed rate of 4 per cent per annum allows interest rates to play their role of automatic stabilizers. When demand for currency is stable, a growing supply of money at a constant rate automatically leads to interest rate corrections that affect the economic situation. If real GDP rises, the resultant growth in currency demand triggers a stabilizing rise in interest rates, bringing equilibrium back to the financial markets and, soon after, the economy as a whole. In a recession the downward movement of interest rates also produces equilibrium.

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[1] Cf. Chrystal (1990).

[2] Although the constitution and the SNB Act are vague on the SNB's mission, assigning the SNB the task of guiding a monetary policy that satisfies the general interest of the country as a whole, the SNB has always interpreted its mission as giving priority to price stability. This interpretation enjoys strong popular support, but mixed political support.

[3] Friedman (1960).

In practice, however, things are not quite that simple, as demand for currency is generally sensitive to interest rate variations. Public holdings of liquid assets are affected by changes in interest rates, often by anticipation. In a free financial market it is normal that participants review their portfolio decisions when a change in interest rates occurs.

Microeconomically, an interest rate hike would cause a rational market participant to sell liquid assets and buy assets that are less liquid but yield a better return. Macroeconomically, this behaviour by market participants causes a drop in the effectiveness of automatic stabilizers: The more sensitive currency demand is to interest rate variations (absolute value and *ceteris paribus*), the smaller the interest rate increase required to establish equilibrium in financial markets following an exogenous increase in transactions volume for a given level of money supply. The inverse is true for a drop in transactions volume. Endogenous changes in interest rates are no longer sufficient to slow or stimulate the economy and re-establish equilibrium in price levels. It follows logically that a more activist monetary policy becomes necessary. The central bank must explicitly vary the money supply countercyclically to strengthen the corrective changes in interest rates. A passive monetary policy is insufficient.

Under these conditions a central bank has only two options. Either it adopts a discretionary monetary policy, in which case it distances itself from the essentials of monetarism, or it adopts a contingent monetary policy rule that explicitly takes the shocks affecting the economy into account.

1.2 Roles defined for monetary aggregates

In a monetarist-based monetary policy regime, a monetary aggregate can play a number of roles. First, it can be a nominal anchor. As the quantitative theory of trade clearly indicates, inflation is an essentially monetary phenomenon. Currency is a natural nominal anchor, a role that is particularly important in the medium term as, while it is well established that excessive sustained monetary growth produces excessive price increases, no one is likely to contend that every movement in prices has a monetary explanation.

Second, a monetary aggregate can be a tool as an intermediate target in the monetary policy decision-making process. A reference value is determined by the monetary authorities concerning the level or growth of the aggregate consistent with price stability in the medium term. In principle, changes in the aggregate in relation to this reference value trigger an automatic correction by the central bank. The correction cannot be instantaneous, although financial market participants, if they are rational in their anticipations, can count on the central bank taking action promptly. In practice, however, the monetary aggregate often plays only the role of indicator; the central bank observes the movements of the aggregate, but is not obliged to routinely react to deviations from the reference value. The deviations act as an alert requiring fresh analysis of the situation by the central bank prior to deciding on its reaction.

When the aggregate can play the role of intermediate target, the central bank should be able to "ignore" the ultimate aim of price stability, perhaps even fail to explicitly define the concept. To define the value of the intermediate target, only an explicit definition of the economy's *nominal* potential for growth is required of the central bank. An implicit definition of price stability enters the definition of the monetary target only when the economy's potential for growth in real terms is explicitly known.

Third, in a monetarist-based monetary policy system, a monetary aggregate is a communication tool. The performance of a monetary aggregate in relation to its reference value gives the central bank a reference framework that can be used to explain the bank's policy to the public, especially the media. This explicit framework enhances monetary policy transparency and can also be used to signal changes in monetary policy direction. When the monetary aggregate plays the role of intermediate target as defined above, it can also be used by the public to evaluate central bank performance. This possibility is far less significant when the aggregate is considered an indicator only.

1.3 Intermediate target or indicator?

To be used as a monetary policy intermediate target, a monetary aggregate should meet the following four criteria as closely as possible.

1. It should be as insensitive as possible to changes in interest rates. The more sensitive an aggregate, the more the central bank is forced to either set variable objectives or tolerate persistent deviation from a constant target. Furthermore, the monetary policy signals sent by an aggregate

sensitive to interest rate variations may be ambiguous.[4] In Switzerland the monetary base is the aggregate least sensitive to variations in interest rates, followed by M3, M2, and M1, the most sensitive.[5]

2. Demand (at least long-term demand) should be sufficiently stable. This condition is necessary so that the signals the aggregate issues can be deciphered and the reference value compatible with price stability estimated. In Switzerland the stability of monetary aggregates has been the subject of a number of studies, the most recent of which are Peytrignet (1996) and Peytrignet and Stahel (1998).[6]
3. The link between money creation and future price stability must be statistically determined and relatively stable. The link between Swiss monetary aggregates and future price increases is discussed briefly in Appendix A1.
4. Finally, the aggregate should be controllable by the central bank. This condition is more easily met by narrow aggregates. By definition the monetary base is the only aggregate completely and at all times controllable by the central bank. In practice such control can produce interest rate volatility that can quickly become unacceptable to the bank. Broad monetary aggregates are more difficult to control directly.

If only the first three conditions are satisfactorily met, the monetary aggregate can no longer fully act as intermediate target. The most it can do is act as an indicator in monetary policy decision-making.

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[4] As inflation is essentially a monetary phenomenon, it is logical to believe that an acceleration in monetary growth is potentially a danger to future price increases. When a monetary aggregate is extremely sensitive to interest rate variations, in some circumstances that fact may be questioned without faulting the theory. Suppose a central bank was obliged to introduce a restrictive monetary policy to fight an undesirable price increase. The result is temporarily high interest rates and below-normal monetary growth. Following such action the economy begins to slow down, a precursor to and cause of the desired drop in inflation. The subsequent drop in interest rates to re-establish normal monetary conditions accelerates monetary growth, which may temporarily exceed the value deemed normal without risking another increase in prices.

[5] Monetary base is defined as total bank notes outstanding with the public and the banks plus banking system reserves with the SNB. M1 is total notes and coins in circulation with the non-banking public plus demand deposits and transactions accounts. Since 1995, M2 adds to M1 savings deposits, M3 term deposits.

[6] The principal results of these studies demonstrate that monetary-base demand is intermittently stable and that demand for M2 and M3 has been stable since the early eighties.

1.4 The Swiss monetary policy concept

Since the advent of flexible exchange rates, the SNB has relied on the theoretical principles summarized in the preceding paragraphs in defining its monetary policy concept. For over 20 years, in an effort to maintain price stability it has applied a concept based on an intermediate target defined in terms of a monetary aggregate.

Since the 1930s, especially since the advent of flexible exchange rates, the ultimate aim of Swiss monetary policy has always been to maintain price stability.[7] This priority even inspired Bernanke et al. (1999) to write that the SNB, along with the Bundesbank, were precursors of central bank management of direct inflation targeting.[8] Whenever there has been conflict between price stability and meeting monetary targets, price stability has often taken precedence over monetary targets. Rich (1999) debated this position.[9] Further on, we will see that whenever there is a rise in the external value of Swiss currency sufficient to seriously threaten economic conditions in our country, the fight against such an increase has taken priority over meeting a monetary target. According to current views, this pragmatic attitude to monetary targets can be interpreted as inspired by a concern to avoid having the deflationary forces produced by enormous surges of the franc negatively affect the Swiss economy. At that time the fight against the negative impact on economic conditions of a rising franc was a priority. The price to be paid for neutralizing these shocks was accepting temporary inflation.

Although SNB official papers often mention the role of intermediate target played by the monetary aggregates in its monetary policy concept, in practice the aggregates have most often played a role of indicator, a key indicator certainly, rather than a role of intermediate target. We will see presently that the concept has changed considerably over time. It has been redeveloped, revised, and re-invented three times, as circumstances demanded.

This description of Swiss monetary policy since the beginning of the seventies makes it easier to describe the effective role of monetary aggregates, an important role not only in communicating Swiss monetary policy, as Mishkin (1999, 588) recently stated, but also in the decision-making process.[10]

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[7] Cf., for example, Swiss National Bank ([1982], 22, 97, and following).

[8] Bernanke et al. (1999), cf. in particular Chapter 4, "German and Swiss Monetary Targeting: Precursors to Inflation Targeting."

[9] Rich (1999).

[10] Mishkin (1999).

2 Swiss Monetary Policy, A Historical Review beginning in 1971

The final years of the fixed exchange rate system under the Bretton Woods Agreement were difficult for Switzerland, as they were for most other countries.[11] With the uncertainty of financial markets, the Swiss franc was seen as a safe haven. In spite of two successive re-evaluations (9 May and 18 December 1971) and the tightening of numerous restrictions on importing capital, maintaining a fixed rate for the franc obliged the SNB to intervene massively on the money market. The money supply increased by 59.6 per cent (annualized rate) in February 1972, M1 by 27.9 per cent in March of the same year, producing a spike in inflation. After a considerable lag, inflation reached 11.9 per cent in December 1973. To halt this disaster the SNB and the federal government jointly decided to allow the franc to float beginning on 23 January 1973 and to introduce an independent monetary policy with a view to re-establishing price stability.

Three separate time periods may be defined since Swiss monetary policy abandoned fixed exchange rates. During the first (1975–78), the SNB defined annual targets for the M1 monetary aggregate. After a transition period (1978–79), a second period (1980–90) can be identified. Over this 10-year period the SNB set an annual target for the monetary base. Following another transition period, marked by temporary loss of the monetary base as monetary compass at the end of the eighties, in 1991 the SNB introduced multi-year targets based on the seasonally adjusted monetary base. The system is formally in force until the end of 1999. In practice, as a result of new exogenous shocks that affected demand for the monetary base, as early as 1996, Swiss monetary policy took a new direction, with the M3 monetary aggregate playing the role of a second indicator in addition to the monetary base.

2.1 Swiss monetary policy from 1975 to 1978: Annual targets based on M1

In 1975, when inflation was far exceeding tolerable levels, the SNB began to implement a monetarist-based monetary policy. To reduce inflation the SNB opted for a two-stage strategy. In the first stage it determined and announced an intermediate monetary policy target expressed as a yearly growth rate for the M1 monetary aggregate. In the second stage the SNB developed a procedure for controlling M1 and keeping aggregate growth in line with the stated objective.

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[11] *Caution*: This is a historic overview of Swiss monetary policy as far as it could be ascertained in 1999. Some information, particularly some data, were perhaps unavailable at the time the monetary policy decisions described were taken.

At the time, M1 was selected by explicit referral to the existence of a stable relationship between money creation measured by M1 and price increases (with a 2- to 3-year lag) and to aggregate controllability. At the time, the SNB was optimistic about its ability to control M1 "without serious problems" (Rich and Béguelin 1985, 82).[12] While recognizing that M1 was not influenced exclusively by the SNB, the Bank could exploit the existing close link between M1 and the monetary base, making it possible to manage M1 through the monetary base management process. As the monetary base is controlled by the central bank, a mandatory and sufficient condition for monetary base influence on M1 value is a stable and foreseeable money multiplier. Specifically, the practice adopted at the time consisted of inferring from the public targets based on M1 an objective based on the domestic money supply at the SNB with the assistance initially of ad hoc methods and later of multiplier forecasts obtained using a purpose-developed small econometric model (cf. Büttler et al. 1979).[13] The targets of both M1 and the monetary base were expressed in the form of mean annual growth rate. The SNB refused to limit itself to a specific growth path for these aggregates during the year. The monetary base fluctuated strongly during the year. These fluctuations were tolerated because they were the result of either seasonal factors or efforts by the SNB to reduce fluctuations in the external value of the franc. Seasonal factors were dominated by changes in "end-of-month loans"; i.e., the increase in liquid assets required by the banks at the end of each month to comply with prescribed minimum reserves.[14] To that was added end-of-quarter demand for non-recurring liquidity by commercial banks (for window-dressing purposes) and occasional demand for funding operations related to managing the Confederation's liquid assets. To avoid interest rate swings the SNB usually met most of these demands for additional liquidity.

To take into account the sensitivity of M1 demand to interest rate variation, the SNB varied the supply of this aggregate by means of a countercyclical policy. When the Swiss economy was having difficulty adjusting to the new flexible exchange regime, to soften high inflation the SNB unhesitatingly set a monetary policy more restrictive than that required to reach the annual M1 growth target. In 1975, inflation stood at 6.7 per cent, risking an under-target M1 growth rate. When the results of the disinflation process began to be apparent, the Bank accepted an above-target 1976 figure to re-establish normal monetary conditions. For 1977 the SNB announced a 1-percentage-point reduction in its annual target to maintain the stability of newly restored prices in the coming years. However, this was short-lived. During this 3-year period the intermediate targets defined on the basis of M1 constrained the monetary policy decision-making process sufficiently to beat inflation. These targets also made it possible to clearly communicate SNB intentions, specifically the 1975 restrictive monetary policy, an easing trend in 1976, and maintenance of price stability by slightly reducing the M1 growth target beginning in 1977. These performances are acceptable, even if it appears, strictly speaking, that the annual M1-based quantitative targets were only partially attained. Table 1 summarizes the results.

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[12] Rich and Béguelin (1985).

[13] Büttler et al. (1979).

[14] Until the end of 1987, under the liquidity-adequacy regulations (Swiss reserve requirements), reserves could be held only at the end of the month.

Table 1

		Annual changes		
Year	**Target**	**Target**	**M1**	**CPI**
1975	M1	6%	4.4%	6.7%
1976	M1	6%	7.7%	1.7%
1977	M1	5%	5.5%	1.3%
1978	M1	5%	16.2%	1.0%
1979	DM/SFr, floor 0.80	–	–	3.6%

Note: CPI, consumer price index.

The 1978-posted M1 growth rate, more than 11 percentage points above the annual target, shows that something unusual happened that year.

2.2 1978–79: Two exceptional years

Although monetary targets have been the central feature of monetary policy since the introduction of flexible exchange rates, the SNB has never wished to follow a rigid monetary strategy and ignore exchange rate shocks. For this reason the SNB has allowed monetary growth to deviate significantly from its target on a number of occasions when the rise in the franc endangered economic conditions in Switzerland. The monetary target did remain a priority except in emergencies. Swiss industry obviously depends on real variations in the franc, and the share of Swiss exports in real GDP was already over 30 per cent by the end of the seventies.[15] It was never possible for the SNB to approach the exchange rate with benign neglect. Nineteen seventy-eight was a year of deep crisis. By the end of 1977, the franc began to rise strongly in both nominal and real terms. By mid-1978, the extent of this increase was sufficient to seriously compromise the Swiss economy. To avoid the deflationary risks associated with a major recession, in early October of 1978 the SNB decided to suspend its M1 target and temporarily replace that target by an exchange rate target in the form of an exchange rate floor for the German mark expressed in Swiss francs. On 1 November 1978, the SNB measures were supported by joint intervention of the American, German, and Japanese central banks. The impact of this exchange rate intervention on the progression of monetary aggregates was dramatic. In the last quarter of 1978, the money supply increased by 27.8 per cent compared to the corresponding period of the preceding year, and M1 rose more than 23 per cent. As the SNB did not know at the end of 1978 when it would be in a position to return to a quantitative strategy, it decided against setting a monetary target for 1979. In the spring of 1979, exchange rate turbulence calmed sufficiently to allow the SNB to gradually absorb a portion of the excess money supply. This process continued throughout the year, enabling the SNB to set a new monetary target for 1980.

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[15] Up to 43 per cent for the first quarter of 1999.

2.3 Swiss monetary policy from 1980 to 1988: Annual objectives defined on the basis of the adjusted monetary base

Beginning in 1980, M1 was abandoned as an intermediate monetary target and replaced by the monetary base. The two-phase process required to steer M1 was abandoned, and SNB attention focused exclusively on changes in the monetary base. The annual target based on monetary base, kept internal to the bank in the old procedure, now became public.

The reasons for changing the target aggregate from M1 to the monetary base are to be found in the turbulent years 1978 and 1979. The situation sufficiently destabilized the demand for M1 to make the monetary multiplier forecast model obsolete. To maintain a quantitative monetary strategy the SNB opted to base its target directly on the aggregate that it directly controlled; i.e., the monetary base. A variety of scientific studies undertaken at the time clearly demonstrated that the change in aggregate was an appropriate measure. These studies produced two especially interesting results: On the one hand, whereas demand for M1, and thus the multiplier that links the aggregate to the monetary base, was at that time sensitive to anticipated variations in the exchange rate for the Swiss franc, monetary base demand was not; on the other hand, the link between money-supply creation and subsequent price increase was similar to the results obtained with M1 prior to 1978–79.

As the monetary base is completely controllable, it soon did a better job than M1 in meeting all criteria necessary for a monetary aggregate to serve as an intermediate target. In December of each year, the SNB announced to the public an intermediate monetary target defined on the basis of the monetary base and valid for the coming 12 months. The target was set as follows: Taking into account a price-increase goal of 0 to 1 per cent and assessment of potential Swiss growth at approximately 2 per cent per annum, the monetary base was evaluated at 2 to 3 per cent, assuming an increase in transactions velocity of this aggregate of not more than 1 per cent per annum to be plausible. An increase of 2 to 3 per cent per annum in the monetary base should reflect a neutral monetary policy. When the SNB decided to implement a more (less) generous monetary policy, it announced an annual objective for growth of its target aggregate greater than or equal to (less than or equal to) the upper (lower) limit of this 2 to 3 per cent range. On the basis of this objective the SNB made every effort to forecast changes in outstanding bank notes for the following 12 months and deduced, from this forecast and the monetary base target, a level growth path for clearing account balances, figures consistent with the Bank's operational objective. The growth path was obviously not completely binding in that, if the situation so warranted, the SNB could deviate from it. However, as far as possible, the Bank attempted to offset such deviations during the year in order to come as close as possible to the annual target set for the monetary base.

In fact, things were a little more complicated in that the monetary objective was not based directly on the monetary base but on a variant that the Bank called "adjusted monetary base," which is simply the monetary base adjusted by the estimated amount of end-of-month loans that the SNB made to commercial banks at the end of each month to enable those banks to meet the minimum requirements of the liquidity-adequacy regulations.

In spite of the change of aggregate, the targets were not reached in 1980 or 1981. This was not because of problems in controlling the aggregate target, as the SNB was always able to steer the monetary base by adequately varying the reserve supply available to the banking system. Rather, the reason can be found on the one hand in an underestimation of monetary base demand interest elasticity and on the other in the fact that the SNB was obliged in 1980 and 1981 to implement a more restrictive monetary policy to combat a marked recurrence of price increases. This in turn was the result of the impact of the second oil shock and, with the usual lags, the excess money creation required to counter the 1978–79 rise of the franc.

One may question the relevance of setting an annual monetary base growth target of 4 per cent for those two years, at which time it could be expected that, under a restrictive monetary policy, the monetary base was certainly not going to increase at such a high annual rate. The response can be found in the fact that in 1979 the SNB did not expect the rise in inflation to be as strong in 1980, as the Bank had already succeeded in withdrawing much of the liquidity placed on the market to defend franc/German mark parity. Neither did it expect the franc to lose over 13 per cent of its value in real terms between 1979 and 1981. To combat this inflationary wave, both domestic and imported, the SNB was obliged to introduce a far more restrictive monetary policy than anticipated at the time the annual target for 1980 was set. To produce a sufficiently high increase in interest rates, the Bank allowed the monetary base to shrink, bringing it far below its 4 per cent target. In 1981, the SNB believed the fight against inflation would be temporary and would not necessarily halt a resurgence of monetary base growth beginning in 1981. (Setting an annual target allows de facto adjustment to the base for calculating the following year's target.) This base drift effect might very well have been sufficient, ex ante, to make a 1981 adjusted money supply annual growth rate target of 4 per cent realistic, if the fight against inflation had already produced results in 1980. But a longer fight than initially expected was necessary to stamp out this stubborn return of price increases. High interest rates significantly depressed the demand for bank notes, exacerbating the drop in the adjusted monetary base in 1981. The price increases began to slow down in 1982, but price stability was not fully restored until 1986.

The policy of gradually reducing inflation was deliberately chosen by the SNB. By applying a smooth monetary policy, it aimed to avoid excessive fluctuations in interest rates and exchange rates, and did so. Furthermore, it had to act prudently, considering the world recession and the slow pace at which the Swiss economy, affected as early as 1982, was once again on a growth path.

In the years that followed, specifically 1982 to 1986, the intermediate targets based on the adjusted monetary base were relatively well-achieved. The over-expenditure of 1987 was an exception, resulting essentially from the additional liquidity made available to the markets to offset the effects of the October stock market crash.

By following a more restrictive monetary policy than forecast for 1980–81, the SNB deliberately opted to prioritize a return to price stability as opposed to meeting monetary targets. To maintain credibility, it was essential that the Bank's various newsletters clearly explained the reasons for these disparities.

On the whole, setting an annual growth target for the monetary base was a fairly positive experience until 1986. In succeeding M1, the monetary base inherited the difficult mission of controlling a largely predetermined increase in inflation, and until 1986 it was successful in its role of nominal anchor, demonstrating to the SNB the path to take to re-establish normal monetary conditions once price stability was again a reality.

Table 2

	Annual variations			
Year	Target aggregate	Target	AMB	CPI
1980	AMB	4%	–0.6%	4.0%
1981	AMB	4%	–0.5%	6.5%
1982	AMB	3%	2.6%	5.7%
1983	AMB	3%	3.6%	3.0%
1984	AMB	3%	2.6%	2.9%
1985	AMB	3%	2.2%	3.4%
1986	AMB	2%	2.0%	0.8%
1987	AMB	2%	2.9%	1.4%
1988	AMB	3%	–3.9%	1.9%
1989	SAMB	2%*	–1.9%*	3.2%
1990	SAMB	2%**	–2.6%**	5.4%

Note: AMB, adjusted monetary base; SAMB, seasonally adjusted monetary base.

* Arithmetic mean of the 12 monetary base growth rates compared to the last quarter of the preceding year, annualized and based on the month of November.

** Mean for the fourth quarter of 1990 compared to the fourth quarter of 1989.

However, if, in Switzerland, price increases follow two or three years after creation of excess money, the inflation of 1989–92 undoubtedly had its roots in some excess creation of money in the years 1986–87. What is the reason underlying this slippage? Is it attributable to selection of the monetary base as the aggregate of reference? Why did the monetary base not signal the danger in time? The responses to these questions are the subject of the following section.

2.4 Another transition period

In describing 1985, the SNB annual report uses the term "satisfactory situation," characterized by vigorous economic growth with a small rise in price increases that the Bank attributed to current conditions and the soaring rise of the dollar, both factors that produced a significant increase in goods imported at the beginning of the year.[16] On the subject of monetary policy the report stresses that this growth of the economy enabled monetary policy to become more restrictive and close in on the 2 per cent growth target for the medium term more rapidly.

Adjusted annual growth of the monetary base slipped from 2.6 per cent in 1984 to 2.2 per cent in 1985, and the growth in broad monetary aggregates slowed from 2.7 per cent to 0 per cent for M1 and from 6.2 per cent to 4.9 per cent for M3. Conversely, as shown in Figure A2.5, credit shot up at an annual rate of over 10 per cent in 1985.

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[16] Swiss National Bank (1986, 7).

Beginning that year the rise in the exchange rate of the franc and its eventual impact on the economic situation began to worry the Bank's senior executives. Figure A2.1 shows that the Swiss franc rose appreciably throughout 1985 and 1986. In 1986, the increase began to strongly depress exports. As the Swiss economy was barely out of the recession that went hand in hand with the disinflationary period of the early 1980s, the SNB was very sensitive to the risks to the economy entailed in the rise of the franc and the drop in exports. Because the target had been reached in 1985 and 1986 (Figure A2.4) and the behaviour of the monetary base made it possible, the reins of monetary policy were slackened. Interest rates suffered no liquidity effect (Figure A2.2) in view of the strong demand for credit, although the supply of M3 rose rapidly by the end of 1985 (Figure A2.5). The negative effect on the economy of reduced exports was evident by 1986, as indicated in the output gap (Figure A2.3).[17] The negative effects worsened in the second quarter of 1986, when the domestic demand for goods and services weakened as well. By mid-1986, the SNB again softened its monetary policy by making additional liquidity available to the commercial banks at month end.[18] The banks' demand for liquidity to meet the end-of-month regulatory requirements had in the preceding months led to temporary interest rate hikes that had a massive impact at month end. To offset this situation the SNB adopted a more flexible attitude, increasing the annual growth rate of assets in clearing accounts held by banks with the SNB from a mean of 2.9 per cent for the first six months in 1986 to 6.1 per cent in the last six months. At the end of 1986, the SNB had a clear intention of backtracking and tightening its monetary policy as soon as encouraging signs were seen in the foreign exchange market. Unfortunately, the events of 1987 did not fit in with those plans.

A number of exogenous events in 1987 frustrated SNB intentions. The first was an unexpected rise in exports in the second quarter of 1987 due to a strong recovery of world trade (Figure A2.6) in spite of the continuing high level of the franc (Figure A2.1). This soon stimulated domestic production, and by the end of 1987 the production gap had closed.

The October 1987 stock market crash required a temporary increase in liquidity volume on the money market. This injection was made as reflected in the rates of change of the monetary base during the final quarter of 1987 (cf. Figure A2.7).

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[17] This analysis is based on data on the economic situation, data that have been repeatedly revised since the mid-eighties, at which time monetary authorities did not have access to such detailed information.

[18] Swiss National Bank (1987, 8).

Finally, two technical innovations significantly influenced demand for the monetary base by early 1988. In mid-1987, a new electronic interbank payment system (known as SIC) was introduced, enabling commercial banks to drastically reduce their need for reserves with the SNB. As a result the SNB could no longer require the banks to hold so much in the way of zero-earning regulatory reserves. A revamped minimum reserve system became a necessity; it came into force on 1 January 1988. As illustrated in Figure A2.7, the banking system needed time to adjust to the changes, time during which demand for clearing account assets by banks, and thus demand for the monetary base, suffered repeated structural shocks. The extent of the drop in demand for the monetary base that began in January of 1988 surprised the SNB and had a significant liquidity effect on money market interest rates. The SNB was not overly concerned because of the virtual absence of interest rate reaction on capital markets, indicating that the financial markets had correctly interpreted these liquidity shocks as temporary. The Bank reacted gradually to absorb the excess market liquidity, raising short-term interest rates to end-of-1987 levels by mid-1988.

These structural shocks did have serious consequences for monetary policy in that they temporarily made the monetary base useless as an indicator. Deprived of its compass, the SNB had no other choice but to adjust to exogenous changes in monetary base demand, causing that aggregate to rise far less than the annual growth target defined for 1988. Using interest rate changes as a compass during this troubled period, the SNB avoided flooding the financial markets with liquidity, which would certainly have further fuelled an inflation that was already beginning to accelerate following excessive money creation in preceding years. The SNB could have realized that money creation was excessive prior to 1988 by observing the acceleration in M3 growth as early as 1986 and bank loan growth in 1984; however, very limited confidence was placed in changes to broad monetary aggregates and bank loans, both factors being deemed unstable. Considering the elements available at the time, we can only observe that this attitude of mistrust was justified: The functions of demand for these aggregates were unstable when estimated from samples that contained only data on the years 1975–88.[19]

The set of exogenous shocks precluded timely action by the SNB to neutralize the expansive effects of the policy in place from mid-1986 to the beginning of 1987. However, aware of the situation, from mid-1988 the

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[19] Peytrignet (1996).

SNB continued to limit the money supply, resulting in a short-term spike in money market interest rates from 1.6 per cent in February 1988 to 9.5 per cent in January 1990. The result of this restrictive monetary policy was that the monetary base reached levels far below the 1989 and 1990 targets in spite of an adjustment to the method used to calculate the annual monetary target, a method designed to take into account structural changes in the monetary base. The annual targets for 1989 and 1990 were based on the seasonally adjusted monetary base rather than the adjusted monetary base as the latter had de facto ceased to exist with the demise of end-of-month peaks in demand for liquidity as the result of regulation reform.

This episode illustrates how technological change can skew the behaviour of a monetary indicator. The temporary consequence of these exogenous shocks was the exclusion of the monetary base as key indicator of monetary policy for 1988 and 1989. The lasting consequences were review of the SNB's monetary policy concept and transition to a far more flexible system.

2.5 Swiss monetary policy from 1991 to 1999: Multi-year targets defined on the basis of the seasonally adjusted monetary base

After several years in which the annual monetary base target was not reached, the SNB was obliged to rethink its monetary policy concept to avoid continuing along a path that in the long run would have damaged its credibility. It did, however, remain convinced that the monetary base would once again be stable after the banking system had completed its adjustment to the above-mentioned technological changes. It wanted to keep this narrow aggregate as a target because of the intrinsic features not shared by any other monetary aggregate; i.e., low sensitivity to interest rate variations, controllability, and daily availability of reliable statistical data that do not require revision. However, an increased need for flexibility became necessary for a number of reasons.

1. The experience of the 1980s had demonstrated that a monetary concept based on annual targets handled exchange shocks badly, a situation that could affect a small country largely open to the outside world. In a situation like this, an independent monetary policy can only be maintained in a framework based on a concept sufficiently flexible to take these shocks into account and avoid credibility problems due to consistent failure to reach an annually defined monetary target.
2. The growing need for flexibility also became apparent in light of the risk of instability associated with financial and technological change (specifically the soaring use of cashless transactions) in the demand function of monetary aggregates; this was particularly true of narrow

aggregates. The SNB had to adopt a monetary policy regime that allowed it to react flexibly to exogenous shocks affecting monetary base velocity.

3. The need for flexibility was even greater—if the monetary base was to be maintained as the target aggregate—because the clearance account share of assets in this aggregate had fallen by 25 per cent before introduction of the SIC payment system and reform of liquidity regulations (less than 9 per cent after reform). Since 91 per cent of the monetary base was made up of outstanding bank notes, offsetting endogenous annual movement in demand for bank notes became extremely problematic. Although always theoretically possible, such action would undoubtedly have led to significant changes in interest rates on the money market, changes that in turn could have produced unwanted changes in the spot rate for the franc. Because demand for outstanding bank notes is a negative function of interest rates paid on savings accounts, following money market interest rate movement with a 2- to 3-quarter lag, the demand for bank notes, and thus the demand for the monetary base, is dominated by endogenous movements that are difficult to offset on an annual basis. Furthermore, such action would have been absurd from a monetary policy point of view. The problem certainly existed before reform of the liquidity regulations; following reform it intensified enormously. Because a relatively weak portion of assets were in monetary base clearance accounts, this aggregate became significantly more sensitive to changes in interest rates.

To respond to this increased need for flexibility, the SNB decided to set a multi-year target based on the seasonally adjusted monetary base for 1991 and subsequent years. By opting for this solution it retained a medium-term monetary compass, at the same time taking into account the drop in short-term controllability of the monetary base. The SNB selected a medium-term seasonally adjusted annual progression of 1 per cent for the monetary base. No specific time frame was announced, only an order of magnitude of three to five years. One per cent represented a figure identical to that used to set annual targets for price increases (1 per cent) and potential real progress of the Swiss economy (about 2 per cent). However, growth in monetary base velocity had increased from 1 per cent to 2 per cent following the reduction in the share of bank reserves in the aggregate. One per cent annual mean growth in the seasonally adjusted monetary base should have sufficed to ensure sustained stability of prices implicitly defined in target calculation.

Early in 1993, because of a concern for transparency, the SNB decided to broaden the framework of its concept in two directions. First, it published a growth path for its target aggregate (cf. Figure A2.7).[20] By so doing, it showed the public that the new concept had been working retroactively since the last quarter of 1989. It did not explicitly explain that the medium-term horizon was a 5-year period. The medium-term objective was a comparison of mean growth of the seasonally adjusted monetary base in the final quarter of each year to the corresponding period of the previous year. The medium-term growth path of the monetary base became a visual aid, serving as a guideline to measure change in the target aggregate. A second measure to enhance transparency was quarterly publication of a seasonally adjusted monetary base forecast for the next quarter so that financial markets would receive information regularly. This publication complemented the Bank's various bulletins, in which seasonally adjusted monetary base movement compared to forecasts and disparities compared to medium-term aggregate growth path were discussed at length.

The SNB began by defining a medium-term growth path clearly above the 1991 monetary base position to take into account the fact that it had been implementing a highly restrictive monetary policy for a number of years and should therefore tend towards normal monetary conditions in the more or less immediate future to ensure that the Swiss economy did not achieve price stability equilibrium by way of a deflationary period.

The SNB, aware of the risk, had attempted as early as 1990 to loosen some of the restrictions in its monetary policy. It was still too soon. The reaction of the currency market was instantaneous. The Swiss franc plunged and imported inflation soared, convincing the SNB to backtrack. In 1991, growth in the seasonally adjusted monetary base nevertheless reached 1.4 per cent, above the 1 per cent mean. Only in mid-1992, when the trend to a price increase slowdown in Switzerland became clear and the European monetary system entered a crisis, was the SNB able to successfully ease its monetary policy. From the end of 1992 to mid-1994, the monetary base came close to its medium-term growth path, but did not yet reach it. As Table 3 shows, 1992 growth in the seasonally adjusted monetary base was again negative (–1 per cent), largely because of a drop in the demand for bank notes. This stemmed from changes in the economic situation and the extremely restrictive monetary policy implemented during the first quarter of the year. In 1993, monetary base growth reached 2.8 per cent, reflecting the looser monetary policy the SNB had wanted for several years. The changes in the target aggregate were less satisfactory beginning in the second quarter of 1994 following a strong appreciation of the franc, in turn producing rapid disinflation and a drop in monetary base demand. The SNB reacted by allowing money market interest rates to fall, but the decrease was

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[20] Cf. *Monnaie et conjuncture* (1993, 57).

Table 3

	Annual change			
Timing	**Target aggregate**	**Target**	**SAMB**	**CPI**
1990	SAMB	1.0%	−2.6%*	5.4%
1991	SAMB	1.0%	1.4%*	5.8%
1992	SAMB	1.0%	−1.0%*	4.0%
1993	SAMB	1.0%	2.8%*	3.3%
1994	SAMB	1.0%	0.6%*	0.8%
Mean		1.0%	0.24%	
1995	SAMB	slope		1.8%
1996	SAMB	of		0.8%
1997	SAMB	medium-term		0.5%
1998	SAMB	growth path		0.0%
1999	SAMB	1.0%		0.6%

* Rate of change calculated for the fourth quarter of a given year compared to the fourth quarter of the preceding year.

timid. Ex ante fears of the risk of increased inflationist anticipation in preparation for the January 1995 introduction of the VAT had made the SNB extremely prudent, in fact, too prudent in hindsight.

The end of 1994 saw completion of the first exercise in setting a multi-year target based on the seasonally adjusted monetary base. The experience of this period teaches the following. With a mean target aggregate growth rate of 0.24 per cent over five years and a negative disparity of 4 per cent with its medium-term growth path by the last quarter of 1994, price stability was restored thanks to a particularly restrictive monetary policy. During this period, priority was once again given to returning to price stability rather than reaching the monetary target. However, by clearly indicating the general direction in which the money supply should be adjusted in the medium term to re-establish normal monetary conditions following the restrictive phase of the early nineties, the medium-term growth path of the seasonally adjusted monetary base played the roles of indicator and monetary anchor that one could expect of it.

The SNB was unable to set the monetary base on its medium growth path in 1994, the Bank's intention at the time it introduced this new reference framework. There are two reasons for this. The first was the need to maintain a restrictive policy longer than expected because of an inflation that was particularly persistent and difficult to overcome, fuelled by an endemic trend towards weakness of the franc during the first part of the decade. At the same time, the aggregate's persistent deviation from its growth path was caused by exogenous shocks that affected both demand for assets in clearance accounts following adoption of new technology that enabled commercial banks to improve liquidity management and demand for outstanding notes with the growing volume of cashless transactions. These two innovations did not destabilize long-term behaviour of the monetary base sufficiently to make the SNB rethink the system.

In December 1994, the SNB decided to continue with the principle of a multi-year target based on the seasonally adjusted monetary base and set a new target for the period from 1995 to 1999. At the same time, to allow for the effects of the above-mentioned innovations on demand for the two components of the monetary base, it decided to adjust the medium-term growth path downward. It did leave the growth-path position above the monetary base to allow a return to "normal" monetary conditions in the years to follow. To avoid the cumulative effect of monetary base growth rates offsetting changes in this aggregate, the SNB decided to stop assessing performance in relation to the medium-term target by recording mean growth rate in the seasonally adjusted monetary base for the last quarter of each year. The Bank thus simplified its monetary policy concept, keeping only the medium-term growth path as a target. The change in monetary base in relation to growth path became the means used to assess the course of monetary policy. The SNB continued to indicate, at the end of each year, anticipated growth in the seasonally adjusted monetary base for the subsequent year. This forecast could be more or less formal, as at the end of 1994 when the SNB announced its 1995 forecast of an annual growth of 1 to 2 per cent in the seasonally adjusted monetary base; or strictly informal, as at the end of 1995 when the Bank simply announced that the monetary base should approach its medium growth path in 1996. At the end of 1996, the SNB reported only that the monetary base should remain above its medium-term growth path throughout 1997. These announcements were intended to provide additional indicators to the financial markets on the course the SNB intended its monetary policy to take in the short term. At the end of 1994, the SNB again announced that it intended to ease its monetary policy a little further to close the gap with the medium-term growth path in 1995. Although changes in the economy were far different from what had been anticipated at the end of 1994 (in 1995 the franc rose by 7.2 per cent; price increases and changes in the economic situation were slower than forecast), in spite of a set of negative factors the SNB was able to produce a 1.4 per cent growth in the monetary base, a rate above the medium-term mean of 1 per cent. To achieve this result the money market interest rate was lowered from 4 per cent to about 2 per cent. This change was confirmed by a 4-step reduction in the SNB discount rate. However, the seasonally adjusted monetary base did not reflect this drastic measure until the end of 1995, with the expected 2- to 3-quarter lag it takes a monetary policy shift to move from affecting short-term interest rates to affecting savings account yields and changes in outstanding notes.

The SNB has continued this expansive monetary policy up to the present day to deal with a financial situation that remains deficient and could produce deflationary pressures if the monetary situation were to return to normal. The ultimate goal of price stability entails deflation prevention.

From mid-1996, the seasonally adjusted monetary base suffered more structural shocks, due to massive transfers by the commercial banks from postal account assets to clearance account assets with the SNB.[21] Furthermore, beginning in February 1997, strong growth in outstanding notes, especially 1,000-franc notes, occurred. After investigating, the SNB soon saw that this growth was unrelated to monetary policy but due to exogenous factors, statistically detectable but of economically obscure origin. These exogenous shocks sufficiently affected the monetary base to cause that aggregate to strongly overestimate the expansion of the monetary policy followed by the SNB in 1997, 1998, and 1999. Faced with uncertainty regarding interpretation of the monetary policy signals issued by the seasonally adjusted monetary base, the SNB informed the public as early as 1997 that it would be using M3 as an additional monetary policy indicator.

The SNB decided against abolishing or further reforming its concept of monetary policy based on money supply. The reason is to be found essentially in the advent of the European economic and monetary union, which entailed in 1999 the replacement of the German mark with the euro as the single European monetary unit in 11 neighbouring countries. Anticipation of this monetary revolution and the fragility of Swiss economic conditions, at that time still largely dependent on export growth, convinced the SNB to pay particular attention to changes in economic conditions and the Swiss franc spot rate. It was able to refocus attention on economic conditions and the exchange rates, considering the moderate growth of M3, compatible with medium-term price stability. Furthermore, the turbulence on the Asian financial markets and the Russian and Brazilian crises naturally slowed recovery of the Swiss economy and growth of M3 in 1998.

At the end of 1999, the concept of a medium-term seasonally adjusted monetary base will come to the end of the road. Owing to instability of the demand for both bank notes and clearance account assets, instability that will apparently continue in the coming years with generalized use of electronic transactions, and as a result of the restructuring of the Swiss banking environment and a variety of technological and financial changes that continue to affect bank liquidity management, it would be impossible for the SNB to set a new medium-term target based on this aggregate. A new monetary policy concept must be developed for the year 2000. It appears that monetary aggregates will still play an important role as indicators under the new concept.

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[21] Holding assets in postal accounts, like holding assets in clearance accounts, are means of holding liquidity that are accepted by law as compliance with liquidity regulations. While assets in clearance accounts are an integral part of the monetary base, assets in giro accounts are not included in that aggregate.

Conclusions

Overall performance of the intermediate monetary target system applied by the SNB from 1975 to 1999 has been satisfactory. The various versions of the concept have on three occasions enabled the SNB, by interpreting the monetary targets pragmatically, to re-establish price stability in Switzerland after the central bank was obliged to intervene to offset the negative effects of exchange market disorder. This concept enabled the Swiss to maintain an independent monetary policy, which certainly contributed to the fact that Swiss interest rates, both short- and long-term, are between 150 and 200 basis points lower than the corresponding German rates, typically the lowest in Europe.

However, if the monetary policy in place over these last 24 years has enabled the Swiss to keep the average inflation rate at 2.6 per cent for 1976–98, a truly honourable result internationally (cf. Figure A2.8), the average price increase is more than twice the "normal" rate of 1 per cent implicit in the calculations of monetary targets. According to Rich (1997, 113), "the problem lay in an inappropriate SNB response to such disturbances as unexpected exchange rate shocks." Using a small macroeconomic model with rational anticipations, he (1997, 140) demonstrated that,

> in the presence of policy lags the SNB faces a conflict between short-term price and output stability, on the one hand, and long-term price stability on the other. In particular, if the SNB is to react optimally to an unexpected shift in asset preferences, it must accept considerable short-term volatility in the exchange rate in order to preserve price stability in the long run.[22]

In conclusion, I am tempted to draw three more lessons from this experience.

The use of monetary aggregates as intermediate targets—or perhaps more realistically as key indicators—of Swiss monetary policy proved effective for bearing in mind the long-term implications of monetary policy decisions and making preventive decisions. To take the year 1992 as an example, the SNB announced to the public its intention of relaxing its monetary policy while inflation was currently high. Another example is 1994, when the signals issued by the monetary base were not taken seriously enough, an overly tight money policy was implemented for too long.

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[22] Rich (1997).

In my opinion the intrinsic difficulties encountered in monetary policy decision-making depend only slightly on the particular type of monetary policy concept adopted as long as that concept is credible. Concept credibility is largely a function of overall performance in reaching its ultimate goal, the fight against price increases, and the care the central bank takes in its public statements on monetary policy. The use of monetary aggregates as intermediate targets within a simple reference framework has proved an extremely effective method of making communication with the public easier. This inspired Bernanke et al. (1999, 53) to write that the SNB has regularly chosen simple rules with complicated explanations rather than complicated rules with simple explanations.[23]

Finally, for a small open economy like Switzerland's, the task of maintaining price stability has been made especially difficult because of its internationally important financial market and the fact that its currency is often used as a safe haven.

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[23] Bernanke et al. (1999).

Appendix A1

Figure A1.1
Correlation between money creation and changes in price increases, recursive samples

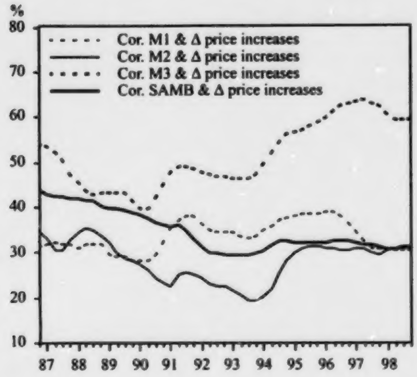


Figure A1.2
Lag in maximum estimated correlation, recursive samples

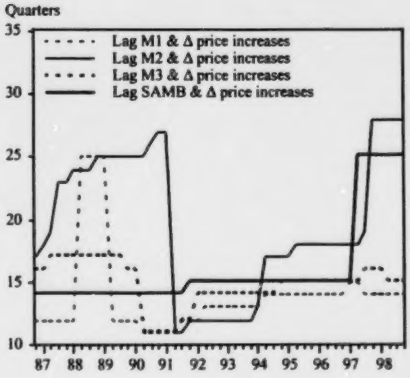


Figure A1.1 shows the maximum correlation coefficients calculated for the changes in Swiss monetary aggregates (M1, M2, M3, and seasonally adjusted monetary base) and the changes in price increases measured on the basis of 12-month growth in CPI. Figure A1.2 shows the lag (quarters) for which the correlation is at a maximum. The estimates are based on a number of samples, each beginning in the final quarter of 1976. The first sample ends in the final quarter of 1986, the second in the first quarter of 1987, and so on up to the final quarter of 1998, the last date for which definitive data on Swiss monetary aggregates are available.

These charts enable measurement of the existence and stability of the link between money creation and the progression of price increases in Switzerland. Figure A1.1 shows that M3 (M2) is the aggregate with the strongest (weakest) correlation to inflation for all (nearly all) samples. The lags where correlation is at a maximum vary enormously for M2 (cf. Figure A1.2); for M3 the lags are clearly more stable, moving only slightly from about 14 quarters. The lag with which the seasonally adjusted monetary base affects price increases was fairly stable, between 14 and 15 quarters, until 1996. In 1997, the lag spiked to 25 quarters, confirming a stability problem for this aggregate, also detected using other statistical methods.

Appendix A2

Figure A2.1

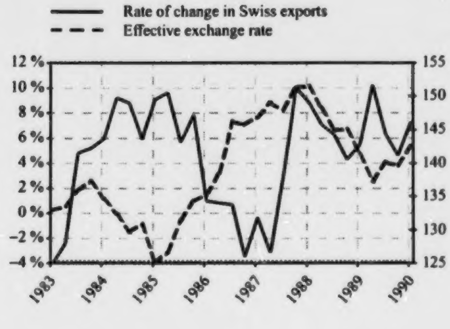


Figure A2.2

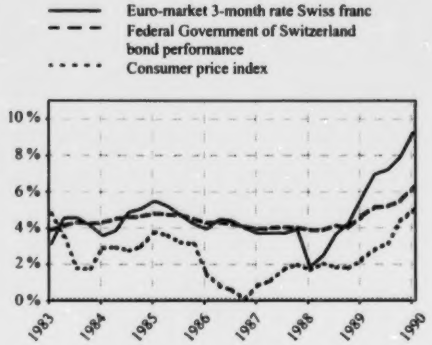


Figure A2.3

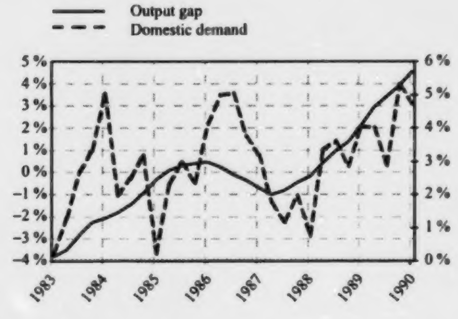


Figure A2.4

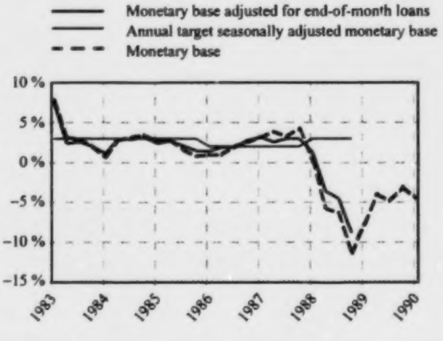


Figure A2.5

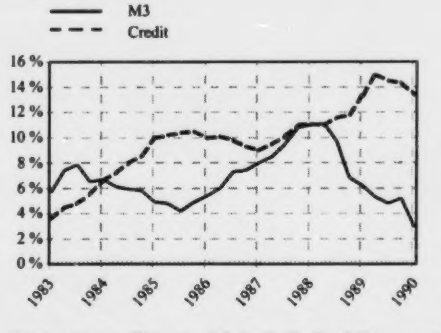
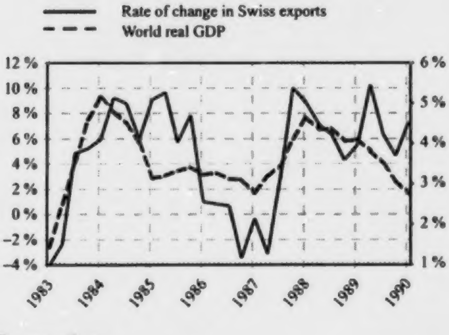
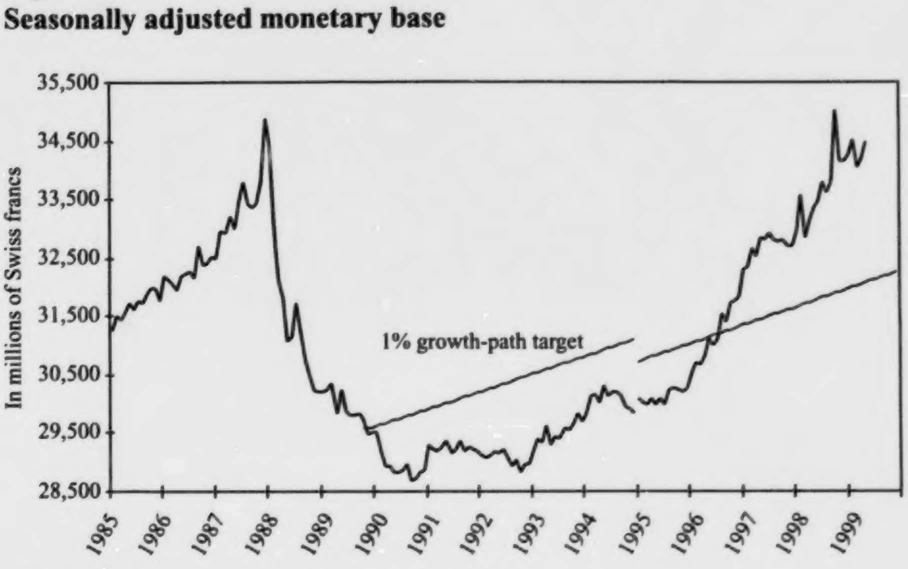


Figure A2.6



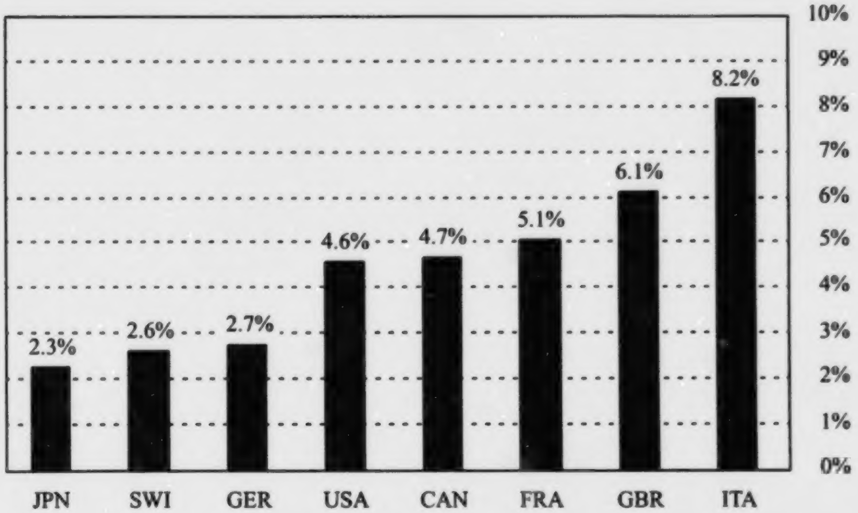
Data source, Figures A2.1–6: Oxford Economic Forecasting.

Figure A2.7
Seasonally adjusted monetary base



Data source: Swiss National Bank.

Figure A2.8
Average year-over-year price increase (CPI), 1976–98



Data source: Swiss National Bank.

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Discussion

Chantal Dupasquier

I was very pleased to receive an invitation from the Bank of Canada's Monetary and Financial Analysis Department to comment on the paper from my colleague at the SNB, and I have had a great deal of pleasure in preparing my comments for today's session.

Before going into my comments on Peytrignet's study, I would like to take a few moments to briefly look at the Swiss economy's recent performance, both in terms of real growth and inflation. Figure 1 shows how GDP has performed, year over year, since 1980. What stands out is the very pronounced slowdown that hit the Swiss economy during the 1990s. In fact, for more than seven years, 1991 to 1997, GDP simply marked time, with an average annual growth rate of only 0.2 per cent. Not until 1998 did the economy show signs of recovery.

If we now turn to inflation, Figure 2 shows the annual change in the CPI for Switzerland and the G-7 countries since the beginning of the 1970s. It is clear from this figure that the results recorded by the SNB on the inflation front compare very well with those of G-7 countries for the whole of this period. With the single exception of Japan, Switzerland had the lowest average inflation rate among these countries between 1976 and 1998. This result is even more striking when we recall that Switzerland has a small and open economy that is highly susceptible to external shocks, a situation that sometimes makes the conduct of monetary policy more delicate than the SNB might wish.

The central purpose of Peytrignet's paper is to examine the theoretical and empirical basis underlying the SNB's conduct of monetary

Figure 1
Annual change in Swiss real GDP

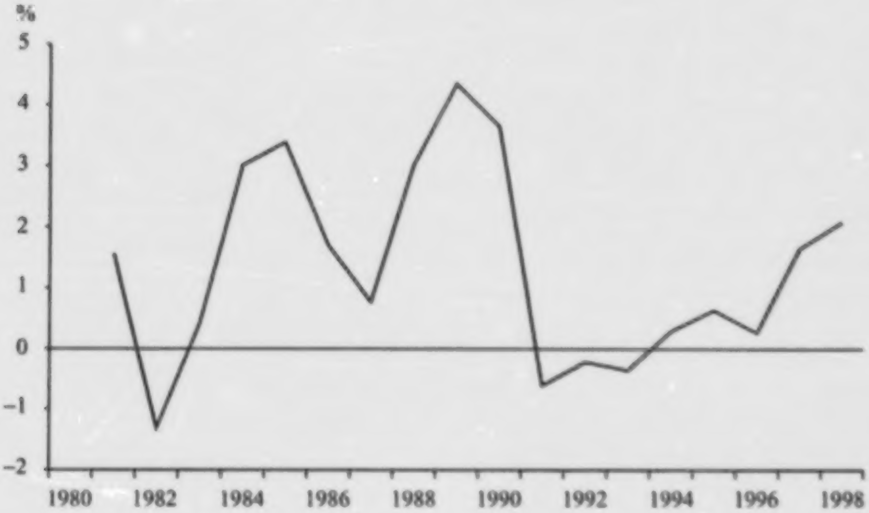
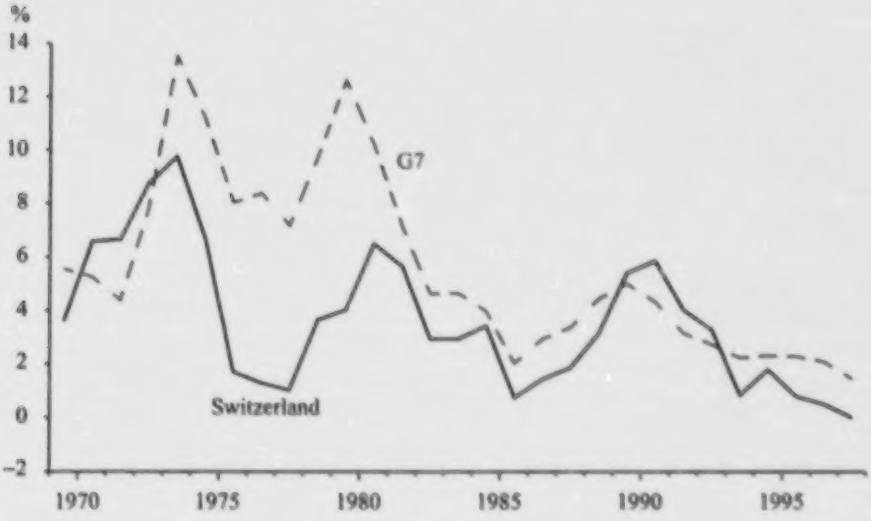


Figure 2
Annual change in CPI for Switzerland and G-7 countries



policy. As he has told us, since the collapse of the Bretton Woods system the SNB strategy has been to set an intermediate target based on a monetary aggregate.

He identified three distinct phases to this strategy:

- 1975 to 1978: annual targets for M1
- 1980 to 1988: annual targets for the adjusted monetary base
- 1991 to 1999: multi-year targets for the seasonally adjusted monetary base

To more clearly understand why the SNB has succeeded so well on the inflation front, we should look first at its mandate. While the Swiss Constitution and the SNB Act are rather vague as to the Bank's mission, which is simply "to satisfy the general interests of the country," the SNB has always interpreted its mission as giving priority to price stability. In itself this mandate is not very different from that of other central banks. Yet the SNB is unique in that it has fixed the growth of the monetary aggregate by taking as its basis an inflation rate of generally between 0 and 1 per cent, an implicit inflation rate that was already being used during the 1970s and 1980s. To my knowledge, few countries were so avant-garde as to tie their monetary target to such a low inflation rate prior to the 1990s, at which time this became a very popular idea among central bankers. A further important aspect for the SNB is that this objective enjoys broad public support, which has no doubt made it easier to meet the target, since the expectations of economic agents are very firmly anchored in this low rate of inflation.

I won't go into the details of the three periods Peytrignet examined. History is history and we cannot change it, but simply interpret it, so I shall focus my remarks on the most recent period.

Since the beginning of the 1990s, the SNB has defined a multi-year target for the seasonally adjusted monetary base, as opposed to an annual target for the preceding two decades. Why this change? If we look at the objectives that the SNB set for itself in the past, we see very quickly that the annual targets for monetary aggregates were not met in more than 50 per cent of cases. Consequently, in order to rescue its credibility the SNB began in 1991 to adopt a framework that it considered more flexible for implementing its policy. However, I want to underline that the adoption of this more flexible framework also coincided with the emergence of a new thrust in the economic literature. Thanks to new developments in econometrics and particularly in cointegration techniques, researchers have developed long-term empirical relationships between money and prices. In this respect, my colleagues in the Monetary and Financial Analysis Department launched a research program on the Canadian economy, and some of their results were presented during this conference. Although

Peytrignet made no explicit reference to long-term demand for money, I have the impression that this is an important element for explaining why the SNB adopted a multi-year intermediate target. I would add another element to explain the SNB's choice of multi-year targets. Since the transmission mechanism for monetary policy extends over a fairly long period of time (one to two years or more), a multi-year objective strikes me as more appropriate given the circumstances in which monetary policy must operate.

On reading his paper I was not completely convinced that the adoption of a target, or more accurately of a monetary target, was the crucial element that allowed the Swiss monetary authorities to meet their inflation goals. Throughout the last three decades the SNB used a specific framework to explain its policy to the public and thus be in a position to readjust its efforts in order to meet its mandate. I think the most important element here is the fact that the Swiss authorities set an explicit target for themselves. In this respect, setting an inflation target may well have allowed them to achieve a low inflation rate.

What lessons should we draw from the Swiss experience? I would point to two:

- Using a target can help to restrain inflation over the long-term.
- Flexibility and transparency would seem to be key ingredients of success.

In closing, I would like to raise some questions that remain unanswered after reading Peytrignet's paper and that perhaps deserve more attention. Although his study deals at length with the credibility of Swiss monetary policy, he had nothing to say about how this element has been integrated into the SNB decision-making process. On this point I refer to certain studies showing that despite the high credibility that the SNB enjoys, the cost to the Swiss economy of reducing inflation (the sacrifice ratio) is not very different, statistically, from the cost to other countries that have definitely not enjoyed the same degree of credibility.

On another point, what role do economic agents' expectations play in the dynamics of Swiss inflation? Inflation has declined sharply, dropping from nearly 6 per cent in 1991 to virtually zero in 1998. I come back again to the performance of real economic growth since the early 1990s, and I wonder if inflation should not have fallen even further, given this very long period of stagnation.

Finally, one more question remains hanging at the end of his paper. Where will the SNB go in the year 2000? Peytrignet was rather vague about the options the SNB is considering for the conduct of its future monetary policy. Is it possible that, like the European Central Bank or many other central banks around world, the SNB will turn to explicit inflation targets, or will it instead continue with monetary targets, which would seem, from many viewpoints, to be more an indicator than an intermediate target?

Discussion

Daniel Racette

Michel Peytrignet drew for us a broad picture describing in great detail the various phases of Swiss monetary policy from 1975 to today.

His description is certainly interesting, if only because it allows us to follow the course of a monetarist experiment that, if not unique, is exceptional at least for its length. Peytrignet's paper goes to the very heart of the topic of this conference in that it recounts the risks that a central bank runs if it uses monetary aggregates as intermediate targets. Since monetary aggregates have receded into the background, or have been completely forgotten, in the conduct of monetary policy in most industrialized countries, a comparative analysis of the Swiss experience should allow us to draw some lessons about the chances of rehabilitating them.

In my comments I shall attempt such a comparative analysis, starting by highlighting the sometimes fascinating similarities between the Swiss experience and our own in Canada. Next I shall look at the aspects that distinguish the Swiss experience in monetary policy. In both cases my goal will be to see whether similarities are sufficiently strong, and differences sufficiently negligible, to permit us to think that at least some aspects of the SNB's use of monetary aggregates could be transferred to other contexts.

Some Fascinating Similarities

Like Canada, Switzerland is what we have come to call a small open economy. The parallel between the two countries in this regard is certainly not complete, since first, the Swiss franc has often been perceived as a safe-haven currency, a status the Canadian dollar has never (as yet) achieved, and second, because Switzerland is not what most people would consider a major producer of natural resources. Yet the two countries are sufficiently similar in terms of the openness of their economies that their central banks cannot afford to ignore exchange rate movements regardless of other strategic elements in the bank's monetary policy. In fact, an analysis of Swiss monetary policy shows clearly that, as with the Bank of Canada during certain episodes in the 1970s and 1980s,[1] the SNB has been preoccupied with movements of its currency, both downwards and upwards (as in the late 1970s), even if this at times has detracted from the credibility of its monetary targets. We may also say that it was precisely because of the openness of its economy that the SNB, like the Bank of Canada, has been obliged to take an approach that, while based on a sound theoretical framework and on important considerations of transparency and accountability, has had above all to be pragmatic; i.e., adaptable to an environment in constant flux.

This may be the basis for several similarities between episodes in Swiss monetary policy and their Canadian equivalents. Thus, just as the Bank of Canada did with the arrival of the then-infamous GST in 1991, the SNB went through the agony of having a value-added tax introduced (in 1995), fear of which, Peytrignet told us, led the Bank to take preventive action that was probably "too prudent." As well, the SNB seems to have reacted to the 1987 stock exchange crash, like many other central banks, by relaxing its policy, no doubt to the detriment of achieving its adjusted monetary base target.

In 1990, the Swiss and Canadian central banks were faced with virtually the same situation. Peytrignet described it as follows: "The SNB, aware of the risk, had attempted as early as 1990 to loosen some of the restrictions in its monetary policy. It was still too soon. The reaction of the currency market was instantaneous. The Swiss franc plunged. . . ." (page 210). The Bank of Canada experienced something very similar when in January 1990 it attempted to force the bank rate down by 29 basis points, something that markets were not expecting. The dollar fell so far that the Bank had to jack interest rates back up again very sharply. It would seem that the SNB's monetary targeting was no panacea under such circumstances.

Finally, we may point to the strongly similar decisions taken by the two central banks in 1975, when they both adopted an intermediate monetary target in terms of the M1 aggregate in order to combat record inflation.[2] In both cases, M1 was chosen because it could be easily controlled and because of the presumed link it bore to inflation.[3] In Switzerland, as in Canada, the experiment seemed to work until 1978, but things started to fall apart in 1979, when the behaviour of M1 became unstable.[4]

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[1] On this point see Courchene (1981) and Howitt (1985).

Although to this point there is a certain parallel between the two situations, the lessons that the two central banks drew from the failure of this experiment with monetary targets were in fact quite different. In 1980, the SNB undertook the redefinition of its monetary targets by adopting a new monetary aggregate, the "adjusted monetary base." In Canada the experience was so painful that the Bank of Canada not only abandoned monetary targeting, but also shunted monetary aggregates to the sidelines of policy-making for at least several years thereafter.[5] Can we explain these widely different attitudes about using monetary aggregates in the policy process on the basis of the factors that distinguish the Swiss and Canadian economic and monetary contexts?

Marked Differences

One noticeable difference between these two contexts is the fact that, according to Peytrignet, Swiss monetary policy has pursued price stability as its ultimate objective since the 1930s, and that means that the SNB was well ahead of other central banks in this regard. Moreover, because price stability enjoys wide popular support, the SNB has long been able to interpret this philosophy fairly rigorously. Thus it regarded the 1975 inflation rate of 6.7 per cent as intolerable, and it defined price stability as keeping the inflation rate well below 1 per cent for the entire period under analysis.

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[2] Switzerland's "intolerable" 1975 inflation rate was 6.7 per cent, while inflation was close to 12 per cent in Canada; however, in the turbulence that followed the end of the fixed exchange regime, Swiss inflation climbed as high as 11.9 per cent in December 1973.

[3] In Switzerland, however, the controllability of M1 was exercised through the monetary base and the multiplier, while in Canada, M1 was controlled along a demand curve that was presumed stable.

[4] With inflation at 1 per cent, the anti-inflationary success of Swiss monetary policy was more convincing, while Canada's inflation rate was higher than 8 per cent in 1978. Moreover, while instability in the demand for M1 may have led the SNB to prefer the monetary base to M1 as a target aggregate for monetary policy in 1980, Peytrignet clearly explained that it was above all the Swiss franc's sharp appreciation after 1978 that persuaded the Bank to abandon its monetary target temporarily in 1978 and 1979.

[5] In fact, monetary aggregates did not officially reappear until 1988, thanks to the study by Hostland, Poloz, and Storer (1988) on the respective merits of 46 different monetary aggregates. But that study merely discussed the qualities of aggregates as indicators without drawing any firm conclusions about their usefulness in the monetary policy process.

It is hard to believe that, having committed itself to a goal of price stability for so long, the SNB could find itself with credibility problems in the face of inflationary pressures, or even deflationary pressures, particularly since it has given itself a firm anchoring point in the form of intermediate monetary targets. Yet this is the case. Experience would suggest that monetary targeting has not been of much help when shocks have disrupted expectations. But Peytrignet's story quickly gives the impression that the problem lies in the fact that Swiss experience with monetary targeting over the last 24 years has been perhaps distorted not only by the necessary transition periods that have given rise to changes in the targeted aggregate or in the monetary-targeting process, but also by successive (unavoidable?) episodes during which priority was given to different objectives, such as the exchange rate (1978–79, 1990), price stability (1980–81, 1995–99), or the monetary aggregate target (other periods). Moreover, his description of the various episodes when monetary targeting was paramount shows that intermediate objectives were generally interpreted fairly flexibly by the SNB, with very mixed results in terms of attaining them. As a consequence, it may be that the targeted monetary aggregates lost their role, in the eyes of the public and of the markets, as a communication tool or even as a credible nominal anchor. Given that the ultimate objective of Swiss monetary policy remains, as always, price stability, we may wonder if it would not have been better under the circumstances to anchor the entire system to an inflation (or price-level) target rather than risk compromising the spirit of monetary targeting in this way.

This notion acquires more force when we note that during the transitional episode of the late 1980s, the lag between money and inflation seems to have been particularly long in Switzerland. Thus, according to Peytrignet, inflation during the period up to 1992, even to 1993 if we look more closely, "had its roots in some excess creation of money in the years 1986–87" (page 205). Yet, since the growth of the adjusted monetary base in those two years was less than 3 per cent, his statement is only understandable if we turn to the behaviour of M3 (his Figure A2.5), which expanded rather rapidly (around 11 per cent), particularly in 1987–88, but dropped back thereafter. Unless something is missing from Peytrignet's paper that would allow us to judge circumstances differently, we must conclude that the monetary policy process in Switzerland is unique if such a short period of monetary expansion could have effects stretching out over nearly six years. In this context the use of monetary targets is a heroic act indeed, since it demands that monetary policy function over an unreasonably long forward time horizon.

The last significant difference that probably helped to keep Swiss monetary policy focused on intermediate monetary targets for so long is the slow pace at which financial innovations have made themselves felt, at least in comparison with Canadian experience. According to Peytrignet, the first signs of financial innovations showed up only towards the end of the 1980s and were apparently limited to technical changes that allowed the commercial banks to hold less in the way of statutory reserves. It was not until 1996 that a new wave of financial innovations robbed the targeted monetary aggregate, the seasonally adjusted monetary base, of its role as an indicator or an intermediate objective. When we think that in Canada a series of major monetary and financial innovations was already underway in the late 1970s,[6] such a delay is surprising. The difference may lie in the fact that the SNB was targeting such a narrow monetary aggregate that it did not have to worry about the financial innovations that were affecting the broader aggregates. Yet if that was the case, it would have been helpful if Peytrignet had made it clear in his paper, or else if he had explained the peculiarities of the Swiss regulatory framework that kept financial innovations so few, or so weak, that they have had no effect on the monetary process. It is obvious that monetary targeting is much more difficult in a context in which the monetary aggregates have to be constantly modified to keep up with technological or financial innovation.

Conclusions

By way of conclusion, I think that Peytrignet's paper allows us to say, once again, that monetary policy is a difficult business in which success requires not only a sound theoretical basis, but a good dose of pragmatism as well. As we in Canada know well, it is particularly difficult in a small open economy in which it is always hard to accept greater exchange rate volatility for the sake of focusing solely on the ultimate goal of price stability. Since we cannot generally afford to neglect the effects of sudden exchange rate shifts, monetary policy becomes even more complicated to conduct and interpret because tactical and strategic considerations are so intertwined.

The SNB was a pioneer in adopting price stability as the ultimate goal of monetary policy. Peytrignet made it clear, in describing the experience of the late 1970s, that achieving this objective in isolation is difficult. His analysis shows particularly well that it would be hard for Canada to keep its sights fixed on price stability if monetary policy in the United States were to allow inflationary pressures there to get out of hand.

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[6] See, for example, the paper presented to this conference by Aubry and Nott.

Given their long experience with price stability as a goal, the Swiss are well placed to confirm the importance of adopting a nominal anchor for monetary policy. Such an anchor must, as Peytrignet's analysis shows, be clearly announced and understood by everyone. The Swiss case is one in which the anchor point for monetary policy was the adoption of intermediate monetary targets. The late arrival of monetary and financial innovations certainly made the SNB's job easier in this respect, and that is no doubt why the Swiss have been able to pursue their monetarist experiment for so long. Whether intermediate objectives were defined on an annual or a multi-year basis, whether the aggregate targeted was M1 (via the monetary base), the monetary base, the (seasonally or otherwise) adjusted monetary base, or more recently M3, monetary aggregates have always had their place in the Swiss monetary policy process over the last 24 years. Peytrignet told us that they will still have a role in monetary policy formulation after 1999. The SNB has kept them because it finds them useful.

Yet an analysis of this long experience with monetary targeting also shows that it is not always easy to keep the course and that the SNB has often had to shift the priority it gives to its different objectives. As I have stressed in my comments, we may wonder if it would not have been easier for the SNB to move, as my colleagues at the Bank of Canada are so fond of proposing, to a simple inflation target.

That said, can we really afford to criticize a central bank that, as Peytrignet's Figure A2.8 shows, has on the whole done better in terms of inflation than any other central bank over the last quarter-century? This success no doubt has to do with the fact that the SNB has always understood that monetary aggregates hold useful information for conducting monetary policy, at least as indicators, and that they must not be ignored. Let us hope that the results of this conference will allow us to conclude that it is possible to bring monetary aggregates back into use in Canadian and other institutional settings.

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General Discussion

In response to Chantal Dupasquier's first comment, Michel Peytrignet recognized that the SNB had indeed failed more than 50 per cent of the time to achieve its annual targets; however, he added that M1 and the monetary base are sensitive to interest rate fluctuations and hence behave in a naturally countercyclical way, and for this reason the occurrence of exchange rate shocks may well mean that annual monetary targets will be missed.

With respect to Dupasquier's second comment, suggesting that it was the adoption of a target, and more specifically a monetary target, that made the SNB so successful in fighting inflation, Peytrignet agreed that what is important is to have a nominal anchor to ensure that long-term considerations are kept in mind in monetary policy decisions.

On Dupasquier's third remark, to the effect that his paper says nothing about how the credibility of Swiss monetary policy is integrated into the SNB decision-making process, Peytrignet declared his belief that credibility was central to the move from annual monetary targets to multiyear targets.

In the wake of the 1990s recession in Switzerland, inflation might have been expected to retreat further, in Dupasquier's opinion. Peytrignet considered it difficult to assess this point during the period in question, since German interest rates rose almost in parallel with Swiss rates following reunification. This tended to diminish the restrictive impact of Swiss monetary policy by weakening the franc and thus fuelling imported inflation. As to the length of the recession that afflicted the Swiss economy during the 1990s, he thought it important to remember that, quite apart from the SNB's tight monetary policy, the Swiss economy also had to cope with

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* Prepared by Denise Côté.

various shocks: the bursting of the 1980s bubble in the construction industry, the onset of restructuring in whole swaths of the Swiss economy, the appreciation of the franc in 1995—the SNB did nothing to counter its appreciation—and the weakness of demand for goods and services in European countries, which were struggling to adjust to the Maastricht Treaty's single-currency norms.

To the question of where the SNB will be heading, Peytrignet said that the Bank is preparing a revised concept of monetary policy for the year 2000 and subsequent years and will issue a statement to this effect in December 1999.

Daniel Racette thought a better explanation was needed as to why the excessive monetary expansion of 1986–87 made itself felt only in 1989 and thereafter. Peytrignet pointed out that, as shown in his Figure A1.2, the average lag between monetary creation and inflation in Switzerland is 14 quarters.

In response to Racette's other comments, Peytrignet agreed that the SNB must struggle constantly to maintain its credibility in the face of multiple inflationary shocks, both domestic and from abroad. He also shared Racette's view that the SNB should be willing to tolerate sharper exchange rate fluctuations; however, he added that although exchange rate fluctuations induced by fundamental economic variables can be tolerated, this is not the case with those induced by the Swiss franc's role as a safe-haven currency, since when these exceed tolerable limits they can threaten entire sectors of the Swiss economy. Fortunately, shocks of this type are rare. As Peytrignet sees it, financial innovations have been slower to arrive in Switzerland than in Canada.

Measuring the Stance of Monetary Policy

Ben S.C. Fung and Mingwei Yuan

Introduction

In this paper we construct a quantitative measure of the stance of monetary policy in Canada using a vector autoregression (VAR)–based approach. Following Blinder's (1998) recent arguments, we base our policy stance measure on the control of inflation. This is appropriate given that the goal of monetary policy in Canada is to keep inflation within a target range of 1 to 3 per cent. We regard the stance of monetary policy as a quantitative measure of whether policy is too tight, neutral, or too loose relative to the objective of keeping inflation constant.[1] If the stance is too tight (loose), inflation will eventually decrease (increase). In other words, a neutral monetary policy stance is consistent with constant inflation in the medium run (Blinder 1998, 33). A quantitative measure of policy stance is useful and important for at least two reasons. First, knowing how tight or how loose its current stance is helps the Bank of Canada determine the course of monetary policy needed to keep inflation within the target range. Second, a quanti-

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[1] We choose constant inflation as the benchmark for our stance measure rather than the midpoint (2 per cent) of the current inflation-control target range because the benchmark of constant inflation is more flexible, since the Bank may choose to keep inflation constant at any given rate within the target range. Besides, the target range has changed over history and may change again when the current target range expires at the end of 2001. Finally, many countries, including the United States, do not have explicit inflation targets. Defining the stance with respect to constant inflation would allow cross-country studies.

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tative measure of stance is important for the empirical study of the transmission of monetary policy actions through the economy.

Currently the Bank uses the monetary conditions index (MCI) as an operational guide for policy. The MCI is a weighted sum of the changes in the 90-day commercial paper rate (R90) and the C-6 trade-weighted exchange rate from a given base period. The relative weighting is 3 for the interest rate and 1 for the exchange rate. These weights are based on a number of empirical studies that estimate the effect of changes in real interest rates and in the real exchange rate on real aggregate demand over six to eight quarters.

The MCI can also be interpreted as a measure of the ease or tightness of monetary conditions relative to a base period; however, it should not be interpreted as a measure of monetary policy stance for several reasons.[2] First, the stance of monetary policy should capture only central bank actions, but the MCI also reflects changes—in the interest rate and the exchange rate—that are not related to central bank policy. For example, a currency depreciation due to a decline in commodity prices will cause the MCI to decrease if the depreciation is not accompanied by a proportional rise in the interest rate. However, the easing of monetary conditions may or may not affect inflation. If the central bank considers the depreciation to be consistent with constant inflation because of the negative impact of falling commodity prices on the economy, then the central bank need not change its stance. Conversely, if the central bank concludes that the currency depreciation is inflationary, it will raise the interest rate and rebalance the MCI to offset the inflationary pressure. In this case the central bank's reaction to depreciation constitutes a change in stance, but the fact that its reaction restores the MCI to its previous level means that the MCI has not changed. Second, the MCI does not consider other financial variables that may be important in the monetary transmission mechanism, such as monetary aggregates, and thereby ignores the money channel of the transmission mechanism. As a result, it is useful to construct a stance measure that captures only central bank actions with respect to inflation control and that includes other important financial variables.

Much of the existing work related to measuring policy stance is VAR-based, following Sims's (1980) seminal work. For the United States, Bernanke and Blinder (1992) and Sims (1992) considered the federal funds rate as an indicator of policy stance. Thus the innovations in the federal funds rate are interpreted as innovations to the Fed's policy. Also using the

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[2] For a discussion of the role of the MCI in the conduct of policy, see Freedman (1995). For a discussion of the MCI as a measure of monetary conditions, see Bank of Canada (1995).

VAR approach, Christiano and Eichenbaum (1992) suggested that the quantity of non-borrowed reserves is a good measure of policy stance, and Strongin (1995) proposed the portion of non-borrowed reserve growth that is orthogonal to total reserve growth. For Canada, Armour, Engert, and Fung (1996) proposed that innovations in the overnight rate (RON), derived using the Choleski approach, could be a good measure of innovations to the Bank of Canada's policy. By comparing the RON innovations to monetary policy actions as described in the Bank's annual reports, they found the RON innovations to be consistent with the intended policy actions since the early 1960s. However, the RON innovations often show perverse price responses in a monthly VAR when the consumer price index (CPI) is used to measure inflation. Fung and Kasumovich (1998) found that M1 innovations produce impulse responses that are consistent with what one would expect from a monetary policy shock, thus suggesting that M1 innovations could be interpreted as innovations to the Bank's policy. All these studies assumed a priori that a single financial variable is the best policy indicator. Unfortunately, little agreement exists on which single variable most accurately captures the stance of policy.

Recently, Bernanke and Mihov (1998) suggested a VAR methodology that can include all the policy variables previously proposed for the United States as particular specifications of a general model. This approach need not assume that a single variable is the best indicator of monetary policy. Bernanke and Mihov constructed a simple model of the market for bank reserves and relied on the central bank's operating procedure to achieve identification of the VAR model. Then they evaluated the different stance indicators, as implied by different operating procedures, by performing statistical tests in the form of testing overidentifying restrictions. Finally, they constructed an overall measure of the stance of monetary policy—the measure being a linear combination of all the policy variables included in the VAR—by studying a just-identified version of the model. This methodology has been applied to Germany (Bernanke and Mihov 1997) and Italy (De Arcangelis and Di Giorgio 1998).

In this paper we apply the Bernanke and Mihov (1998) methodology to Canada. The stance of monetary policy is assumed to be a single-dimensional unobserved variable that responds to the development of inflation and determines the evolution of inflation. Policy stance, though unobserved, is reflected in the behaviour of a set of observed financial variables, which we call policy variables or indicators. These policy variables are directly influenced by monetary policy within a given period. To obtain a measure of policy stance, the key decision is determining what variables should be included as policy variables.

We consider four financial variables—M1, the term spread, the overnight rate, and the exchange rate—because of the following considerations.[3] First, since the reserve requirement was eliminated in Canada in 1994, Bernanke and Mihov's model of the reserves market is not directly applicable. Reserves can be replaced by excess reserves or Bank of Canada advances to chartered banks, and then the overnight rate would be the instrument of monetary policy. However, the implementation of the Large Value Transfer System (LVTS) in February 1999 complicates the issue, since excess reserves or advances vary closely around zero at the end of each day. Because of these considerations, we replace the market for bank reserves with the market for M1. Previous VAR studies (noted above) have shown that M1 reveals useful information about the stance of policy, and Laidler (1999) suggested using a transactions-money aggregate such as M1 to obtain information about the stance of policy. Second, we consider the term spread, defined as the spread between short-term and long-term interest rates, as a candidate variable in the stance measure. Previous studies have found the term spread to be a good predictor of output growth and a good measure of policy stance. Third, we consider the overnight rate to be the Bank's policy instrument; this is consistent with the monetary policy framework in Canada. Moreover, many recent studies have suggested that a very short-term interest rate captures well the stance of monetary policy. Finally, the exchange rate is added as a potential variable, as in De Arcangelis and Di Giorgio (1998), because Canada is a small open economy where the exchange rate plays an important role in the transmission mechanism. In sum, these four variables have been found to be informative indicators of monetary policy stance in previous studies.

After estimating the model, we construct a stance measure that includes both the endogenous and exogenous components of monetary policy. The measure is constructed as a linear combination of the four policy variables included in the model. We use the measure to examine the Bank's overall policy; for example, whether the Bank accommodates various types of shocks and to what degree. Before doing this, though, we find it instructive to examine the exogenous innovations to our stance measure. By looking at the impulse-response functions of the orthogonalized innovations to the stance measure, we can examine the dynamic responses of other variables in the VAR to monetary policy innovations. We find the results to be consistent with the expected effects of a monetary policy shock; i.e., following an expansionary policy shock, the interest rate and the term spread decline, output and the price level increase, and the Canadian dollar depreciates relative to the U.S. dollar. We also find that the time series of the policy innovations is consistent with the historical performance of exogenous monetary policy with respect to inflation control. These results suggest that the orthogonalized innovations to our stance measure do behave like a monetary policy shock. Comparing the stance measure with the changes in inflation and output growth, we find that the stance is broadly consistent with the evolution of inflation since the 1970s. The estimated weight for each of the four policy variables included in the stance measure suggests that the overnight rate plays the most important role in capturing the stance of monetary policy.

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[3] By not focusing on the reserves market, this model can be applied to any country in which there is no reserve requirement or in which reserves do not play an important role in the transmission mechanism.

The rest of our paper is organized as follows. The VAR-based methodology is discussed in the next section. The model of the market for money and the identifying restrictions are described in section 2. The data and the estimation method are described in section 3. The results are reported and discussed in section 4. In the last section we offer our conclusions and some suggestions for future research.

1 Methodology

Our methodology follows that of Bernanke and Mihov (1998). Suppose that the "true" economic structure is the following unrestricted linear dynamic model:[4]

$$Y_t = \sum_{i=0}^{k} B_i Y_{t-i} + \sum_{i=0}^{k} C_i P_{t-i} + A^y V_t^y, \tag{1}$$

$$P_t = \sum_{i=0}^{k} D_i Y_{t-i} + \sum_{i=0}^{k} G_i P_{t-i} + A^p V_t^p, \tag{2}$$

where B_i, C_i, A^y, D_i, G_i, and A^p are square coefficient matrices. Equations (1) and (2) partition the variables under consideration into two groups: a non-policy block (Y) and a policy block (P). The set of policy variables includes variables that are potentially useful as indicators of the stance of monetary policy; e.g., short-term interest rates. The central bank might not have complete control over the policy variables because they are also influenced by other shocks; however, it might have a significant influence on these variables within the current period. Consider the exchange rate, for example: When the central bank implements monetary policy by setting the short-term interest rate, it takes into account the contemporaneous reaction of the exchange rate and the subsequent effects on the economy. Non-policy variables (that is, variables not related to central bank policy) include other macroeconomic variables, such as output and prices, whose responses to monetary policy shocks we would like to examine. In this system, each variable is allowed to depend on current or lagged values (up to k lags) of any variable in the system. The vectors V^y and V^P are mutually uncorrelated "structural" or "primitive" disturbances.

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[4] Capital letters indicate vectors or matrices of variables or coefficients; lower-case letters indicate scalars.

Most of the recent VAR work on measuring monetary policy has considered only a single variable, which is assumed a priori to contain the relevant information; i.e., P is a scalar, say p, instead of a vector. In this case, equation (2) can be written as

$$p_t = \sum_{i=0}^{k} D_i Y_{t-i} + \sum_{i=0}^{k} g_i p_{t-i} + v_t^p, \tag{3}$$

which may be interpreted as the policy reaction function. The central bank sets policy after observing other variables that are represented by the first two terms in equation (3). The term v_t^p is the orthogonalized innovation in p_t and represents the exogenous monetary policy shock. Thus the single indicator of monetary policy, p, consists of an endogenous component, which describes the central bank's response to the state of the economy, and an exogenous component.

For a single measure of policy stance in the United States, for example, Bernanke and Blinder (1992) considered the federal funds rate, Christiano and Eichenbaum (1992) considered non-borrowed reserves, and Kim (1999) considered M1. In Canada, Armour, Engert, and Fung (1996) examined the overnight rate, Fung and Gupta (1997) considered the overnight rate and excess cash reserves, and Fung and Kasumovich (1998) examined M1. One simple approach to identifying the effects of policy shocks on the non-policy variables is by assuming a recursive causal ordering among the variables in the VAR. For example, policy shocks are assumed not to affect non-policy variables within the same period because of, for example, adjustment costs; i.e., the elements of the vector C_0 are all 0. Once the VAR is estimated, a Choleski decomposition of the covariance matrix provides an estimated series for the exogenous monetary policy shock, v_t^p. Impulse-response functions for all variables with respect to the policy shock are then calculated and examined.

In this paper we consider the case that no unique indicator of policy exists, or that even if a single measure of stance does exist, we do not know for certain what it is. In the Bernanke and Mihov (1998) methodology there is no need to assume that a single variable is the best indicator of stance because P can have two or more elements. Their approach used estimates of the central bank's operating procedure to identify policy stance from a set of policy indicators. The approach also allows us to examine cases in which the central bank uses hybrid operating procedures—for example, targeting an interest rate while smoothing exchange rate fluctuations. In this case, both the interest rate and the exchange rate contain information about the stance of monetary policy, but both variables may also be affected by demand or other shocks. Even if there is only a single policy indicator, their approach allows us to choose among the candidate indicators statistically.

When P has more than one element, suppose that one element of the set of shocks v_t^p in equation (2) is a shock to monetary policy, denoted as v_t^p. To identify v_t^p and the dynamic responses to that shock, we again make the timing assumption that innovations to variables in the policy block do not affect variables in the non-policy block within the period, or $C_0 = 0$. Now suppose that we write the system equations (1) and (2) in standard reduced-form VAR format by moving the contemporaneous terms Y_t and P_t to the left-hand side. We define U_t^y to be the VAR residuals corresponding to the Y block and U_t^p to be the component of the residuals corresponding to the P block, which is orthogonal to U_t^y. Then equations (1) and (2) can be rewritten as a reduced-form VAR:

$$Y_t = \sum_{i=1}^{k} H_i^y Y_{t-i} + \sum_{i=1}^{k} H_i^p P_{t-i} + U_t^y, \tag{4}$$

$$P_t = \sum_{i=1}^{k} J_i^y Y_{t-i} + \sum_{i=1}^{k} J_i^p P_{t-i} + \left[(I - G_0)^{-1} D_0 U_t^y + U_t^p\right]. \tag{5}$$

Suppose that we estimate equations (4) and (5) by standard VAR methods and then extract the component of the residual of equation (5) that is orthogonal to equation (4), denoted by U_t^p. Comparing equations (4) and (5) with equations (1) and (2), it can easily be shown that U_t^p is related to V_t^p by the following:[5]

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[5] The reduced-form VAR residuals and the structural shocks are related by:

$$\begin{bmatrix} I^y & 0 \\ B_{21} & I^p \end{bmatrix} \begin{bmatrix} U_t^y \\ U_t^p \end{bmatrix} = \begin{bmatrix} A_{11} & 0 \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} V_t^y \\ V_t^p \end{bmatrix},$$

where I^p and I^y are identity matrices, $B_{21} = (I - G_0)^{-1} D_0$, $A_{11} = (I - B_0)^{-1} A^y$, $A_{21} = ((I - G_0)^{-1} D_0 (I - B_0))^{-1} A^y$, and $A_{22} = (I - G_0)^{-1} A^p$. The non-policy block can be identified by restricting A_{11} to be lower triangular when the variables in Y are arranged in a recursive causal order. The policy block is identified by imposing proper restrictions on A_{22} (discussed in the next section). It can easily be shown that $U_t^y = (I - B_0)^{-1} A^y V_t^y$ and $U_t^p = (I - G_0)^{-1} A^p V_t^p$.

$$U_t^p = (I - G_0)^{-1} A^p V_t^p. \tag{6}$$

Equation (6) can be rewritten, dropping subscripts and superscripts, as

$$U = GU + AV. \tag{7}$$

Equation (7) is a standard structural VAR system that relates observable VAR-based residuals U to unobserved structural shocks V. This system can be estimated and identified by conventional methods. Given the parameter estimates, we can recover the structural shocks, V_t^p, including the exogenous monetary policy shock v^s, by inverting equation (6):

$$V_t^p = (A^p)^{-1}(I - G_0)U_t^p. \tag{8}$$

The dynamic responses of all variables to the policy shock can then be examined by the associated impulse-response functions. Since our focus is on identifying the monetary policy stance, this approach allows us to concentrate on the identification restrictions in the policy block by modelling equation (6). To identify the policy block, we rely on a model of the market for money to impose parameter restrictions on the policy variables. To identify the non-policy block of equation (5), we impose a recursive causal ordering of the non-policy variables and restrict A^y to be diagonal. In other words, if output is ordered first in the non-policy block, it will not react contemporaneously to other variables in either the policy or non-policy blocks.

Given the estimated coefficients of the VAR, we can also obtain the following vector of variables:

$$(A^p)^{-1}(I - G_0)P, \tag{9}$$

which are linear combinations of the policy indicators, P. The orthogonalized VAR innovations of the variables described by equation (9) correspond to the structural disturbances V in equation (8), and one of these variables has the property that its VAR innovations correspond to monetary policy shocks. This can be seen most easily by considering the case where P contains only one variable, say the overnight interest rate. In this case the overnight rate is a measure of policy stance, and the orthogonalized innovations to the overnight rate correspond to exogenous monetary policy shocks. When P is a vector of policy variables, the estimated linear combination of policy variables included in P can be used to measure policy stance, including both the endogenous and exogenous portions of policy, and the shock to this measure represents the exogenous monetary policy shock. In subsequent sections we examine the impulse-response functions of a shock to policy stance to see whether it is consistent with what we expect the effects of a monetary policy shock to be. We also compare our stance measure with changes in inflation and with output growth.

2 The Model

To apply the Bernanke-Mihov methodology, the most important decision is which variables should be included in the policy block. Bernanke and Mihov (1998) modelled the reserves market in the United States, including in the policy block only variables in the reserves market, such as total reserves, non-borrowed reserves, and the federal funds rate. Using a similar strategy for Germany, Bernanke and Mihov (1997) included total reserves, Lombard loans, the call rate, and the Lombard rate. In Canada the overnight market for reserves and other short-term funds has evolved continuously since the 1950s (see, for example, Lundrigan and Toll [1998]). One of the most important changes related to our study is the phasing-out of required reserves beginning in 1991 and their eventual elimination in 1994. Moreover, implementation of the LVTS in February 1999 caused further changes in the overnight market, and this makes modelling that market more difficult. For example, Bank of Canada advances to direct clearers vary closely around zero at the end of the day. Thus, the model of the reserves market used in previous studies is not appropriate for Canada.

To apply the Bernanke and Mihov (1988) methodology to Canada, we make the following modifications. First, we add an equation for determining the Can$/US$ exchange rate. Second, instead of using reserves variables, we use other quantity variables. A money aggregate such as M1 seems to be a natural candidate as a replacement for the reserves because M1 has been shown to generate dynamic responses consistent with the expected effects of monetary policy shocks in Canada (see, for example, Fung and Kasumovich 1998). The idea is to model the contemporaneous relationships among variables in the policy block (as discussed in the previous section). The variables considered in the policy block are: the overnight rate (*RON*); the real money supply, defined as M1 divided by the CPI (*M*); the term spread, defined as the spread between R90 and the 10-year-and-above Government of Canada bond yield (*TS*); and the price of foreign exchange (*PFX*). The overnight rate is considered to be the Bank's policy instrument. All these variables have been found to contain useful information about monetary policy and are influenced by monetary policy within the same period. The model, written in innovation form, is described by the following set of equations:[6]

$$\text{Money demand: } u_M = -\beta u_{TS} + v^d \tag{10}$$

$$\text{Money supply: } u_{TS} = \alpha^d v^d + \alpha^s v^s + \alpha^x v^x + v^b \tag{11}$$

$$\text{Overnight rate: } u_{RON} = \phi^d v^d + \phi^b v^b + \phi^x v^x + v^s \tag{12}$$

$$\text{Exchange rate: } u_{PFX} + \gamma_1 u_M + \gamma_2 u_{TS} + \gamma_3 u_{RON} = v^x \tag{13}$$

Equation (10) relates the innovation in the demand for money (negatively) to the innovation in *TS* and an autonomous shock to money demand; thus, the equation can be interpreted as a short-run money-demand function.[7] Equation (11) determines the amount of money that commercial banks choose to supply by influencing *TS*. The commercial banks are assumed to respond to money-demand shocks (v^d), monetary policy shocks (v^s), and exchange rate shocks (v^x) when determining their money supply. The term v^b is a money-supply shock, which can be interpreted as a credit shock or financial market shock. Here we assume that currency is mainly demand-determined, and thus credit supplied by commercial banks determines the supply of money to the economy.[8]

Equation (12) describes how the Bank sets the overnight rate. This equation assumes that the Bank observes and responds to shocks to the total demand for money, shocks to the supply of money, and shocks to the exchange rate within a given period, with the strength of the response given by the coefficients ϕ^d, ϕ^b, and ϕ^x. Setting $\phi^d = 0$, for example, implies that the Bank completely offsets the money-demand shock to keep the overnight rate from changing. The term v^s represents exogenous monetary policy shocks that we want to identify. Equation (13) is the exchange rate equation, which relates the innovation in the exchange rate to the innovations in all the other policy variables. The equation says that the innovations in the exchange rate can be decomposed into two components: the responses to innovations in other variables in the policy block, plus an exogenous exchange rate shock.

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[6] The vector U^p is the component of the VAR residuals corresponding to the policy block, which is orthogonal to the VAR residuals corresponding to the non-policy block U^y. The total VAR residuals corresponding to the policy block are equal to a linear combination of the orthogonal and the non-orthogonal components [see equation (5)]. Since U^p can be obtained from the estimation of the VAR model, we consider only policy variables when modelling the market for M1; we focus on modelling those policy variables that do not respond to variables in the non-policy block within the same period.

[7] Heller and Khan (1979) estimated a money-demand function that includes the whole term structure of interest rates, finding the results to be better than traditional money-demand functions.

[8] Laidler (1999) discussed the role of the banking system's supply of nominal monetary liabilities in the monetary transmission mechanism.

We can write the relationship between U and V as $(I-G)U = AV$ [see equation (7)]:

$$\begin{bmatrix} 1 & \beta & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ \gamma_1 & \gamma_2 & \gamma_3 & 1 \end{bmatrix} \begin{bmatrix} u_M \\ u_{TS} \\ u_{RON} \\ u_{PFX} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ \alpha^d & 1 & \alpha^s & \alpha^x \\ \phi^d & \phi^b & 1 & \phi^x \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} v^d \\ v^b \\ v^s \\ v^x \end{bmatrix} \tag{14}$$

We can then invert relationship equation (14) to determine how the monetary policy shock, v^s, depends on the VAR residuals:

$$v^s = w_M u_M + w_{TS} u_{TS} + w_{RON} u_{RON} + w_{PFX} u_{PFX}, \tag{15}$$

where

$$w_M = \left[\frac{(\phi^b\alpha^d - \phi^d) + (\phi^b\alpha^x - \phi^x)\gamma_1}{(1-\phi^b\alpha^s)}\right],$$

$$w_{TS} = \left[\frac{(\phi^b\alpha^d - \phi^d)\beta - \phi^b + (\phi^b\alpha^x - \phi^x)\gamma_2}{(1-\phi^b\alpha^s)}\right],$$

$$w_{RON} = \left[\frac{1 + (\phi^b\alpha^x - \phi^x)\gamma_3}{(1-\phi^b\alpha^s)}\right],$$

and

$$w_{PFX} = \frac{(\phi^b\alpha^x - \phi^x)}{(1-\phi^b\alpha^s)}.$$

Equation (15) shows that the monetary policy shock is a linear combination of all the VAR residuals in the policy block, with the weight on each variable equal to some combinations of the model parameters. A measure of the stance can be constructed using the same weights on the corresponding variables as in equation (9).

The model has 14 unknown parameters (including 4 shock variances) to be estimated from 10 residual variances and covariances. To identify the model, further identifying restrictions are needed. Bernanke and Mihov (1998) used two strategies for achieving identification. The first is to model the central bank's operating procedures, such as interest rate targeting, to achieve overidentification of the model. Thus, the model and the proposed operating procedure could be tested in the form of a test of overidentifying restrictions. The second strategy is to impose only enough restrictions to just identify the model, thus allowing the derivation of a measure of monetary policy stance as a linear combination of all the policy variables.

In this paper we focus only on just identifying the model. To achieve just identification we must impose four additional restrictions. We choose these restrictions so that the weight on each variable remains non-zero. We also avoid imposing too many restrictions on the reaction functions of the central bank or commercial banks so that these functions can be determined by the data. As a result, we impose the restrictions $\gamma_1 = 0$, $\gamma_2 = 0$, $\gamma_3 = 0$, and $\phi^d = 0$.[9] This implies that the measure of the monetary policy shock is

$$v^s = w_M u_M + w_{TS} u_{TS} + w_{RON} u_{RON} + w_{PFX} u_{PFX}, \tag{16}$$

where

$$w_M = \frac{\phi^b \alpha^d}{(1 - \phi^b \alpha^s)},$$

$$w_{TS} = \frac{\beta \phi^b \alpha^d - \phi^b}{(1 - \phi^b \alpha^s)},$$

$$w_{RON} = \frac{1}{(1 - \phi^b \alpha^s)},$$

and

$$w_{PFX} = \frac{(\phi^b \alpha^x - \phi^x)}{(1 - \phi^b \alpha^s)}.$$

The first three restrictions imply that the innovation in the exchange rate does not respond to any other variables contemporaneously and thus is purely stochastic. The last restriction implies that the Bank fully offsets shocks to money demand to keep the overnight rate from changing. However, the Bank may accommodate shocks to the credit market and to the exchange rate, depending on the values of ϕ^b and ϕ^x.

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[9] These parameters were found to be very close to 0 when they were unrestricted. The generalized method of moments (GMM) estimation method we use also influences our choice of restrictions, since the variance-covariance matrix derived from the model is also a function of the model parameters. To recover the unrestricted coefficients, all the elements in the covariance matrix have to be non-trivial functions of these unrestricted parameters.

3 Data and Estimation

To estimate the model we need to specify the non-policy variables Y and the policy variables P. In all VARs estimated in this paper we use the following non-policy variables: monthly real GDP at factor cost (*GDP*), the CPI (*P*), and the world commodity-price index (*PCOM*). The commodity-price index is used to capture the non-policy-induced changes in inflation pressure that the Bank may react to when setting policy. Many U.S. studies have found that including *PCOM* helps resolve the price puzzle (after an expansionary policy shock, prices decrease initially rather than increase) usually found in the VAR literature. The three non-policy variables are ordered: *PCOM*, *GDP*, and *P*. It is reasonable to order *PCOM* first, since Canada is a small open economy with a relatively small influence on world commodity prices. Moreover, a commodity-price shock will have an immediate effect on the Canadian economy because of Canada's relatively large resource sector. We also include some U.S. variables—the CPI, GDP, and the federal funds rate—as exogenous variables to capture the close link between the Canadian and U.S. economies.[10] Policy variables include M1, the overnight rate, the Can$/US$ exchange rate, and the term spread.

Since the VAR model is identified by imposing contemporaneous restrictions, monthly data are more appropriate than quarterly data. It is more difficult to defend the identification assumption of no contemporaneous feedback from policy to the economy at the quarterly frequency. All Canadian data are from CANSIM except *PCOM*, which is the world commodity-price index (non-fuel) from the *International Financial Statistics* published by the International Monetary Fund. All variables in the VAR are in log levels except interest rates, which are in levels. Data are available from 1961 through 1999M3. We begin our estimation in 1971M1 to avoid the fixed exchange rate regime in the 1960s. We also consider two subsamples—1971M1 to 1991M12 and 1982M1 to 1999M3—to allow for the structural break around 1982 due to the termination of money-growth targeting and the introduction of inflation-control targets in 1991.[11] Selected series of the data set used are plotted in Figure 1.

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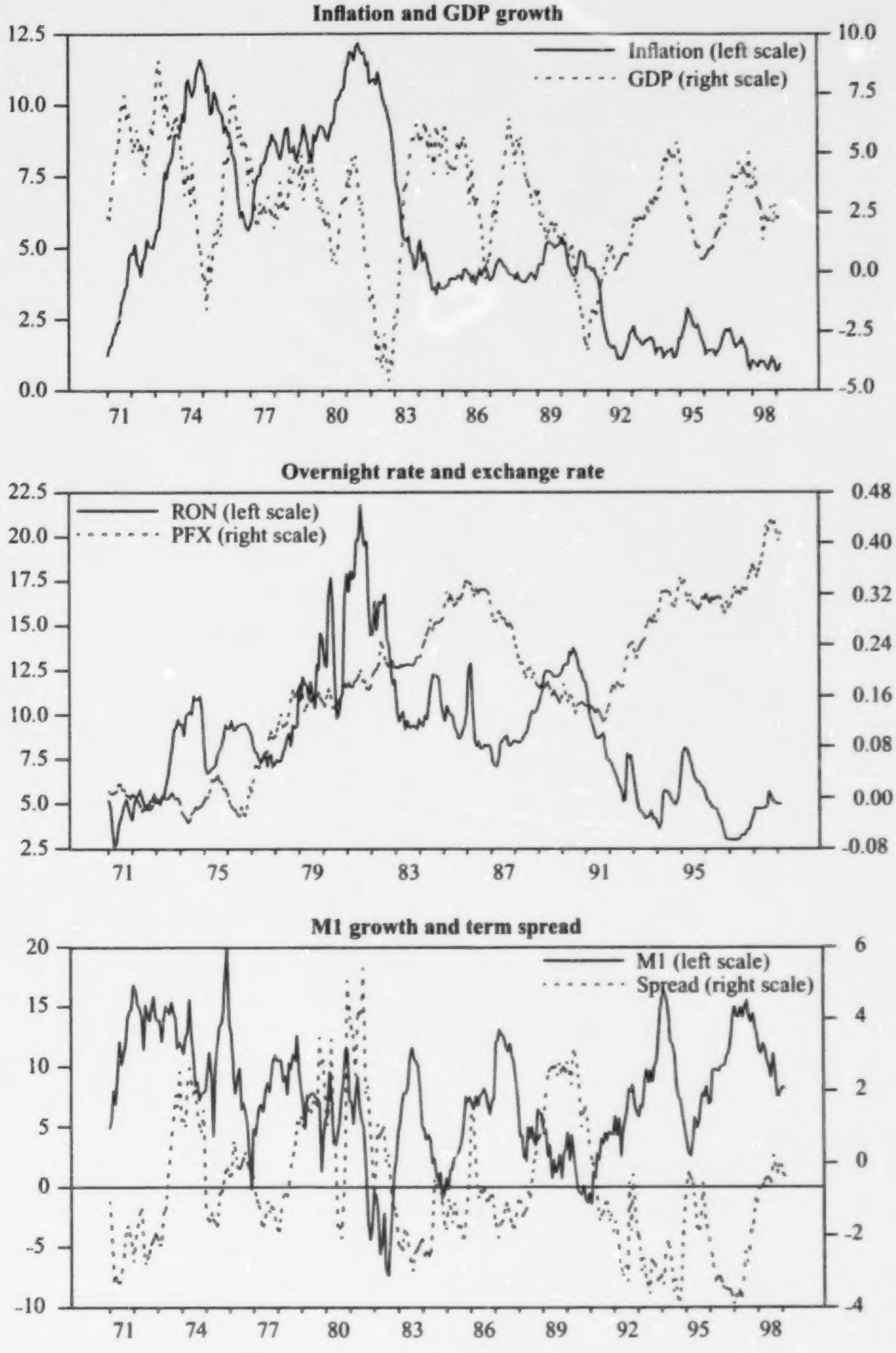
[10] The U.S. variables are important because they help to resolve the price puzzle found in previous work on Canadian policy shocks. Including *PCOM* alone does not solve the price puzzle. Recent work on monetary policy shocks in Germany (Bernanke and Mihov 1997) and Italy (De Arcangelis and Di Giorgio 1998) also found the price puzzle, even when *PCOM* was included in the VAR.

[11] See section 4 for more discussion.

Figure 1
Selected time series used in the estimation



The models are estimated by a two-step, efficient GMM procedure.[12] In the first step the coefficients of the VAR model are estimated using equation-by-equation ordinary least squares. In the second step the second moments implied by the theoretical model being estimated are matched to the covariance matrix of the policy sector VAR residuals. In the VAR estimation, 12 lags (one year) are included.[13]

4 Results

4.1 Estimation results

The full sample runs from 1971M1 to 1999M3. The estimation results are reported in panel A of Table 1. The short-term interest rate elasticity of money demand, β, is estimated to be 0.0025, but is not significant. The parameters (α^d, α^s, and α^x) in the term-spread equation are all significant. A positive value of the parameter α^d implies that when a positive money-demand shock occurs, the short-term interest rate rises to clear the money market. The parameter estimate $\alpha^s = 0.58$ indicates that the term spread would increase by 58 basis points when the overnight rate rises by 100 basis points. The term spread rises less than one-for-one with the overnight rate because of the two offsetting effects of a monetary policy shock: a liquidity effect and an expected-inflation effect. An unexpected currency depreciation would lead to an increase in the short-term interest rate, an increase that could forestall further currency depreciation ($\alpha^x > 0$).

The parameters ϕ^b and ϕ^x in the overnight rate equation are not statistically significant. The parameter ϕ^b captures the reaction of the central bank to innovations in the term spread. A negative value of ϕ^b implies that when a positive innovation occurs in the term spread due to, for example, an unexpected tightening of credit conditions in financial markets, the Bank would lower the overnight rate to provide more liquidity to the overnight market. The Bank would also raise the overnight rate in response to an unexpected currency depreciation, resulting in a positive sign of ϕ^x. Neither ϕ^b nor ϕ^x is significant, suggesting that the Bank does not generally respond vigorously to credit or exchange rate shocks within a given period. This may indicate that current information in financial markets is not fed into the policy rule. The Bank tends to maintain a desired overnight rate level according to the expected information at the beginning of any given period.

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[12] We also estimated the models with maximum-likelihood estimation, and the results were quite similar.

[13] The number of lags included in the estimation is determined by a likelihood-ratio test.

Table 1
Estimation results

A. Full sample: 1971M1–1999M3

Parameter estimates of the structural model ($\phi^d = \gamma_1 = \gamma_2 = \gamma_3 = 0$)

β	α^d	α^s	α^x	ϕ^b	ϕ^x
0.0025	9.3397	0.5765	14.8391	−0.0423	2.6769
(0.0016)	(3.7092)	(0.1100)	(4.1197)	(0.1237)	(3.9931)

Weights in the measure of stance

w_M	w_{TS}	w_{RON}	w_{PFX}
−0.2215	0.0392	0.9655	−3.0835
(1.7560)	(0.1144)	(0.0253)	(4.1713)

B. First subsample: 1971M1–1991M12

Parameter estimates of the structural model ($\phi^d = \gamma_1 = \gamma_2 = \gamma_3 = 0$)

β	α^d	α^s	α^x	ϕ^b	ϕ^x
0.0010	5.5888	0.5929	9.4496	−0.0756	−0.0117
(0.0017)	(4.6977)	(0.0446)	(5.1955)	(0.0467)	(5.2851)

Weights in the measure of stance

w_M	w_{TS}	w_{RON}	w_{PFX}
−0.4058	0.0703	0.9574	−0.6794
(0.4560)	(0.0427)	(0.0266)	(5.4864)

C. Second subsample: 1982M1–1999M3

Parameter estimates of the structural model ($\phi^d = \gamma_1 = \gamma_2 = \gamma_3 = 0$)

β	α^d	α^s	α^x	ϕ^b	ϕ^x
0.0036	18.8656	0.5370	19.5508	−0.0779	3.4896
(0.0020)	(6.6653)	(0.0713)	(3.7084)	(0.1065)	(4.1283)

Weights in the measure of stance

w_M	w_{TS}	w_{RON}	w_{PFX}
−1.4015	0.0623	0.9604	−4.7102
(1.9500)	(0.0628)	(0.0538)	(4.3158)

Notes: The parameters of the structural model are estimated by a two-step, efficient GMM procedure. The standard errors are in parentheses.

The estimated weights for the four policy variables (w_M, w_{TS}, w_{RON}, and w_{PFX}) in the stance measure are also reported in panel A of Table 1. The parameter estimates have the anticipated signs. An expansion in money supply or a currency depreciation represents an easing (a negative weight), and a rise in the short-term interest rate relative to the long-term rate, or an increase in the overnight rate, represents a tightening (a positive weight). According to the estimate of the weight on M (–0.22), a one-percentage-point increase in M1 implies a reduction in the stance measure of 0.22 basis points; however, the standard error of the weight suggests that it is not significant. The weight on the exchange rate is estimated to be -3.08, which means that a depreciation of one Canadian cent reduces the stance measure by 3.08 basis points. The weight on the term spread is 0.039 and is not significant. Only the weight on the overnight rate, 0.97, is statistically significant. These results suggest that the overnight rate contains the most significant amount of information about policy stance.

Parameter instability is always a concern for time-series analysis because of changes in monetary regimes and financial structures. In the mid-1970s, Canada experienced significant inflation problems. In response, the Bank of Canada introduced a program of "monetary gradualism," under which M1 growth was controlled within a gradually falling target range. In the meantime the government imposed wage and price controls. Monetary gradualism was abandoned in November 1982.[14] In February 1991, inflation-control targets were adopted jointly by the Bank of Canada and the Government of Canada.[15] Thus, it is desirable to split the full sample period into two subsamples: 1971M1 to 1982M10 and 1982M11 to 1999M3. However, the large number of variables (10) and lags (12) in the VAR model cause a degrees-of-freedom problem in the estimation if these subsamples are used. To eliminate this problem, we revise the first subsample to 1971M1 to 1991M12, which excludes data for the years after inflation targets were introduced. We revise the second subsample to 1982M1 to 1999M3, which excludes the period of money targeting.

The estimation results of the two subsamples are reported in panels B and C of Table 1. Most of the estimates of parameters and weights for the two subsamples are similar to those for the full sample, suggesting that these estimates are quite robust to the use of different sample periods.[16]

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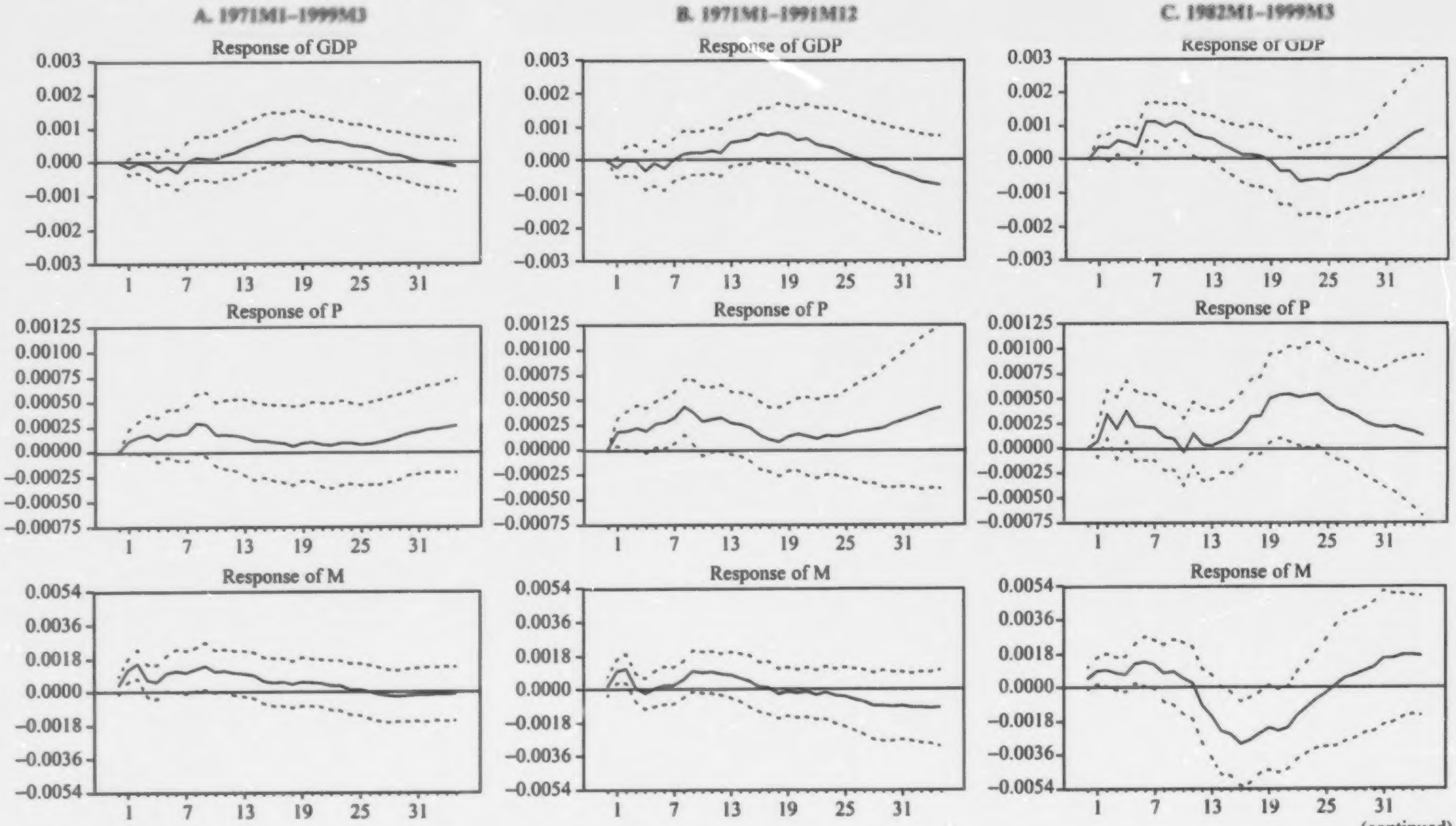
[14] Following the adoption of monetary gradualism in 1975, the Canadian dollar depreciated sharply. The Bank of Canada responded by tightening policy more than was needed to meet the M1 targets. Because of financial innovations, M1 targets were abandoned in November 1982.

[15] The inflation rate in 1991 was 5.9 per cent as measured by the CPI. The goal was to reduce inflation to progressively lower levels to ensure a favourable climate for long-lasting economic growth. By December 1993, inflation had been reduced to 2 per cent. At that time the government and the Bank agreed to extend the target range (1 to 3 per cent inflation) for three more years, to the end of 1998. In February 1998, with inflation well contained, the existing targets were extended to the end of 2001. The government and the Bank agreed that before that time they would jointly determine an appropriate long-run target consistent with price stability.

[16] There is evidence that some parameter estimates are unstable across the subsamples. We will address this problem in future research by considering non-linear models.

Figure 2
Impulse-response functions to a shock in ν^{S}

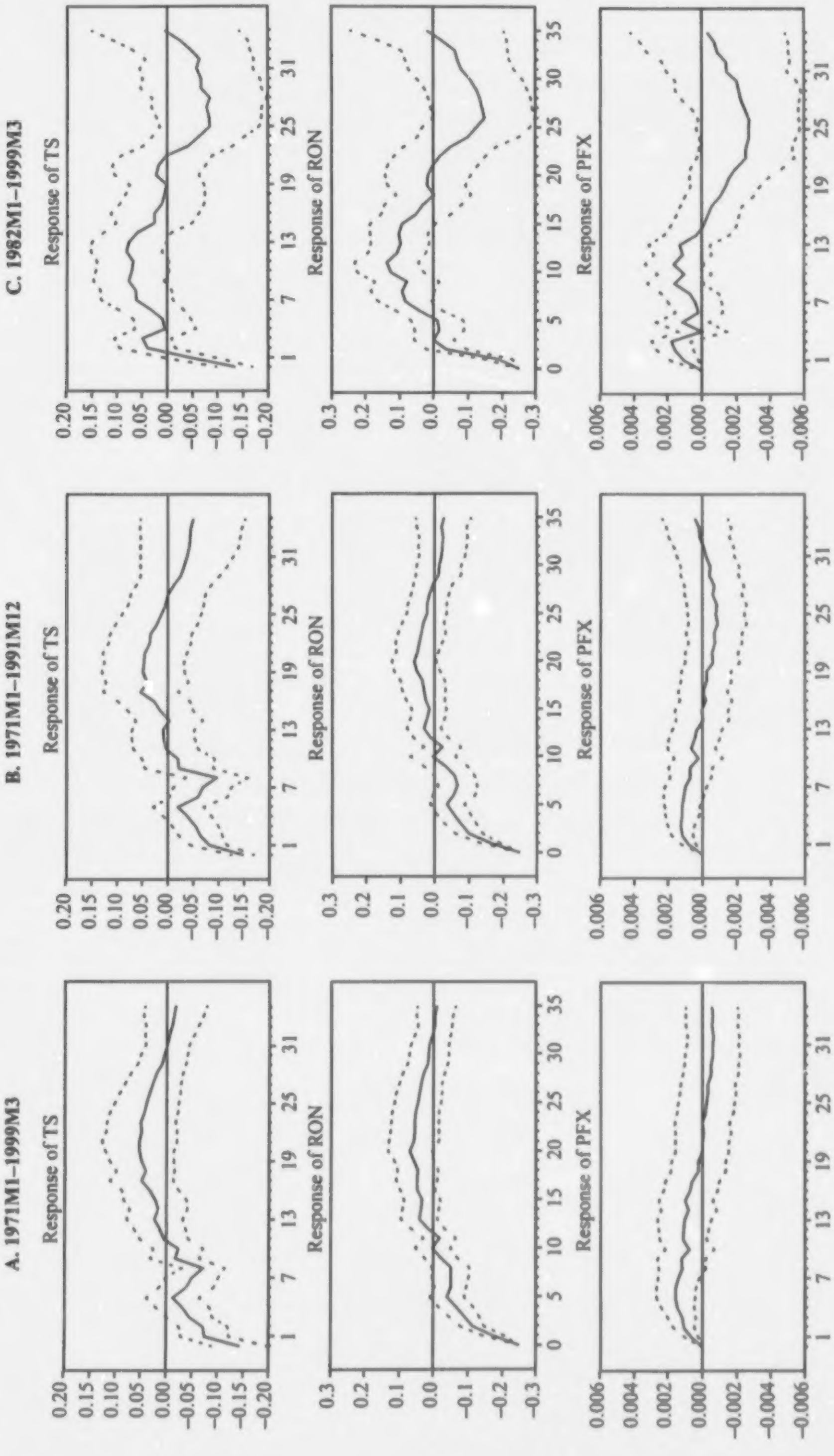

A. 1971M1–1999M3

B. 1971M1–1991M12

C. 1982M1–1999M3

(continued)

Figure 2 (continued)
Impulse-response functions to a shock in v^s



4.2 Impulse responses to monetary policy shocks

Our purpose is to derive a good measure of monetary policy stance. The orthogonalized innovation to policy stance corresponds to an exogenous monetary policy shock (see section 2) and thus in evaluating the stance derived from the model, it is instructive to examine the impulse-response functions of such monetary policy shocks.

Figure 2 shows the estimated dynamic responses of real output, real money, the price level, the term spread, the overnight rate, and the exchange rate to a monetary policy shock (v^s). The responses of the commodity-price index are not reported, since Canadian monetary policy has only a small influence on the commodity-price index. The experiment we consider is an expansionary policy shock that results in a decline in the overnight rate by 25 basis points $(u_{RON} = -0.25)$. The two dashed lines represent the 95 per cent confidence bands.

Column A in Figure 2 shows the results for the full sample. Following an expansionary policy shock, the overnight rate decreases by 25 basis points, and the term spread decreases by 15 basis points. The overnight rate responses show a liquidity effect that lasts for almost 10 months and is significant for the first 8 months. After 10 months the anticipated inflation effect dominates, resulting in a rise in the overnight rate. The overnight rate finally returns to its pre-shock level 3 years after the shock. The responses of the term spread are very similar to those of the overnight rate, but are smaller in magnitude. This similarity may be due to the fact that R90 and the overnight rate are highly correlated and that monetary policy shocks have relatively small effects on the long-term rate. Output starts to increase 6 months after the shock and peaks around 18 months after the shock. The responses become significant 1 year after the shock and are significant for 9 months. Compared with output, the price level responds more quickly and the responses are more persistent: It starts to increase 1 month after the shock and is significant for about 9 months. After the expansionary policy shock the exchange rate increases (the Canadian dollar depreciates) significantly for 9 months, but after that the responses are not significant. Money demand increases because of the lower opportunity cost of holding money (the lower short-term interest rate) and an increase in aggregate economic activity. The money responses are significant for about 9 months after the shock.

Columns B and C in Figure 2 show the responses for the two subsamples. The responses of the overnight rate and the term spread are quite similar across the sample and subsamples. However, the liquidity effect is more short-lived in the second subsample—the term spread decreases for only about 3 months and the overnight rate decreases for

6 months. The second subsample includes the 1990s, when the Bank has brought inflation down and has been keeping it well within the target range. Thus, it is somewhat puzzling that the expected inflation effect becomes dominant so much sooner than in the sample and the other subsample. Also, the responses of the overnight rate and the term spread are more volatile in the second subsample. The responses of output and the price level in the first and second subsamples are qualitatively similar, but are different in terms of their speed and significance. In the first subsample, output responds to the shock slowly, and the responses are not significant throughout the horizon considered. However, in the second subsample, output responds more quickly, and the responses are significant for the first year after the shock. For both subsamples the responses of the price level are similar to that of the full sample. The price level responds quickly and the responses are persistent. The responses are significant for the first year in the first subsample, but more volatile in the second subsample—the responses are significant for the first 9 months and also for another 6 months about 18 months after the shock. The Canadian dollar depreciates after the expansionary policy shock, but the depreciation is significant only in the first subsample. In the second subsample, the Canadian dollar appreciates significantly 18 months after the shock, possibly because of the significant increase in the overnight rate 9 months after the shock.

4.3 Exogenous monetary policy shocks

Once the model is estimated, the exogenous monetary policy shock v^s can be identified. Since v^s is very volatile, we plot the 18-month moving averages of v^s in the top panel of Figure 3.[17] The zero line defines the benchmark at which all policy actions are fully anticipated. If no further monetary policy shocks occur, inflation and output growth will stay on the long-run trend. If v^s is above (below) the zero line, then policy is tighter than expected (easier than expected).

Next we compare the major monetary policy episodes with the derived policy shocks. The description of the episodes is adapted from Table 1 in Armour, Engert, and Fung (1996), which provides a chronology of major episodes from 1961 to 1994 based mainly on Bank of Canada annual reports. To illustrate the impact of policy shocks on future inflation and output growth, we plot, in the middle and bottom panels of Figure 3, the derived monetary policy shocks, the 2-years-ahead change in inflation, and the 18-months-ahead change in output growth. To facilitate our discussion we divide the sample into four periods: 1973–78, 1979–83, 1984–88, and

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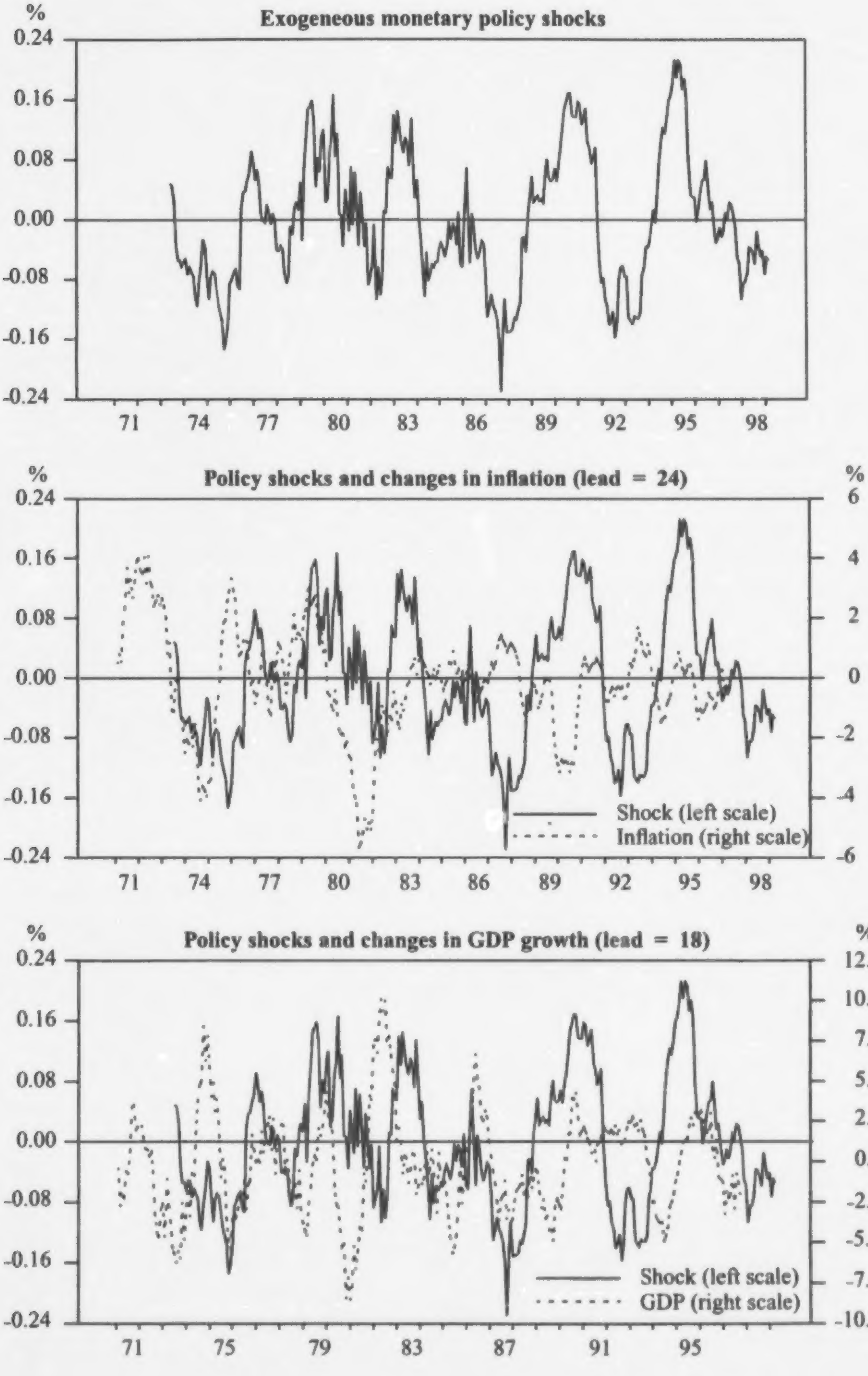
[17] We consider an 18-month moving average because it takes, on average, about 18 to 24 months for monetary policy to affect the economy.

Figure 3
Monetary policy shocks, inflation, and GDP growth



Exogeneous monetary policy shocks

Policy shocks and changes in inflation (lead = 24)

Policy shocks and changes in GDP growth (lead = 18)

1989–99. The top panel of Figure 3 shows that policy shocks were mostly easier than expected in the first and third periods, but mainly tighter than expected in the second period. Comparing these shocks with inflation depicted in the top panel of Figure 1, we can also see that the derived policy shocks are consistent with the trend of inflation in each of the four periods.

From 1973 to 1978 the derived policy shocks in Figure 3 suggest that policy stance was easier than expected in general except from mid-1976 to early 1977. Thus, except from 1975 to 1976, inflation was on an upward trend for most of the period until mid-1981, so the change in inflation was mostly positive in the middle panel of Figure 3. According to Armour, Engert, and Fung (1996), during 1973–75 the Bank generally pursued an expansionary policy. In 1974, inflation increased to a double-digit level, and output growth surged in 1976 to around 6 per cent (see Figure 1). In the summer of 1975, the Bank of Canada came to the view that underlying inflationary pressure was rapidly building up to a critical level, and in September 1975, the Bank raised the Bank Rate substantially and continued to push up short-term interest rates in the first part of 1976. However, in the second quarter of 1976, M1 growth slowed abruptly, and in the third quarter, M1 growth was below the lower limit of the target range. To move M1 growth back into the target range, the Bank lowered interest rates through the last two months of 1976 and into 1977.

The policy shocks shown in Figure 3 suggest that policy was mostly tighter than expected from 1979 to 1983 and also rather volatile. Policy was tighter than expected in 1979, but gradually conformed to what financial markets expected in 1980. Inflation declined sharply from its peak of about 12 per cent in 1981 to around 5 per cent in 1982. Output growth also dropped from 5 per cent in 1981 to negative values in 1982 and 1983 as a result of the recession. Policy was easier than expected for a short period from mid-1980 to mid-1981, then tighter than expected again until 1983. Thus, the change in inflation was mostly negative in this period. In 1979, the Bank raised the Bank Rate in January, July, September, and twice in October (Armour, Engert, and Fung 1996). Tight policy continued until the summer of 1980. From the second half of 1980 to 1981, policy eased substantially and output growth started to rebound about 18 months later. Inflation, however, remained on a slight downward trend. In the second half of 1982, there was strong downward pressure on interest rates. Concerned about the dollar's weakness, the Bank acted to moderate the decline in short-term interest rates. Thus, policy remained relatively tight, resulting in further declines in inflation and output growth in 1984.

From 1984 to mid-1988, our policy-shock measure suggests that policy was relatively easier than expected—with one brief exception. In late 1985 and early 1986, the Canadian dollar was under downward pressure and the Bank reacted strongly to support it (Armour, Engert, and Fung 1996). Our policy-shock measure indicates that policy was as expected or slightly tighter than expected during this period, suggesting that policy did not deviate too much from an expansionary stance. Because of the expansionary stance, inflation was mainly on a slight upward trend, rising from 3 per cent in 1984 to around 5 per cent in 1989. Output growth remained rather stable in the period.

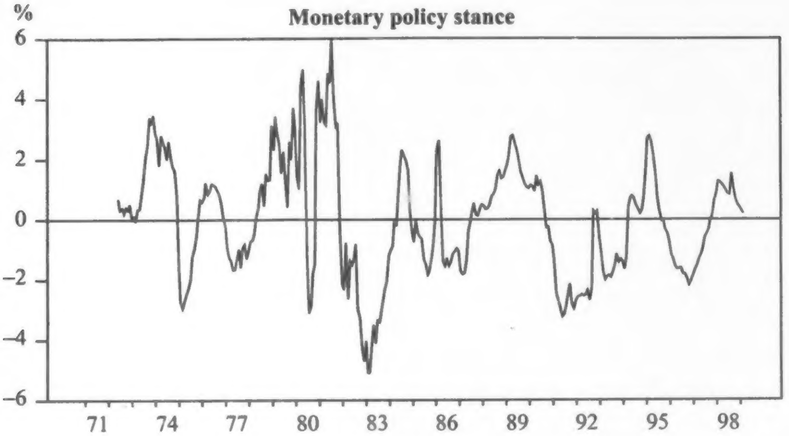
Our measure in Figure 3 shows that policy was tighter than expected from late 1988 to 1991, then became easier than expected for about two years until early 1994. Policy was again tighter than expected from early 1994 until 1996. Since 1996, policy shocks have been slightly easier than expected or close to expectations. Again, this description of policy is consistent with the monetary policy episodes mentioned in Armour, Engert, and Fung (1996) and with the evolution of inflation since 1988. In the second half of 1988, the Bank began to implement a contractionary policy that was consistent with the objective of price stability. The Bank strongly and consistently resisted an upsurge in inflation until the first half of 1991. Thus, inflation was reduced between 1990 and 1992. Output growth also slowed down between 1989 and 1991 and became negative in 1990 and 1991 (a recession, see Figure 1). From 1992 to 1993, policy was expansionary. As a result, both inflation and output growth followed a slight upward trend about 18 to 24 months later. From 1994 to 1996, policy was tightened to ensure that inflation would fall into the inflation-target range, which depressed real activity and brought inflation down. Since 1996, policy has been neutral or slightly easy, but output growth has remained depressed. Output growth decreased in 1997 and 1998, a decrease that may be due to reduced government spending and other structural changes. Inflation has remained fairly constant at a very low level since 1996, though on a slight downward trend.

4.4 Measure of policy stance

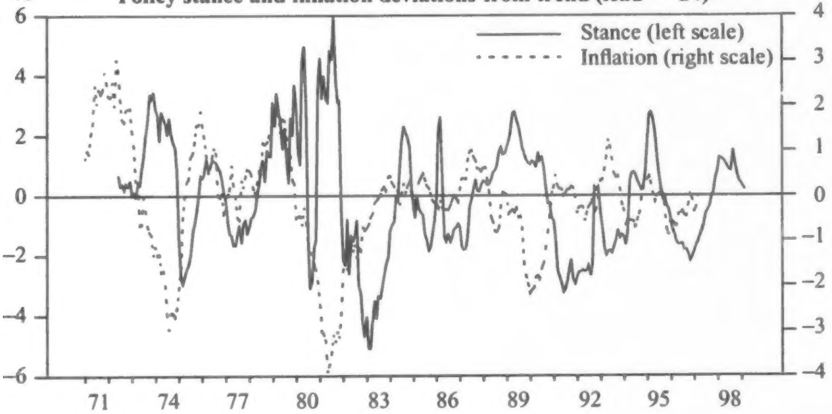
As we discussed in section 1, we can also construct, using the same weights reported in Table 1, a stance measure that includes both the endogenous and exogenous components of policy. Following Bernanke and Mihov (1998), we normalized the stance at each date by subtracting from it an 18-month moving average of its own past values. This procedure has the effect of defining zero as the benchmark of neutral monetary policy, indicating that policy has not deviated from the average stance in the past 18 months. This normalized stance measure captures the pressure on recent inflation. Thus, when the stance is neutral, inflation will not move away from its 18-month moving average. A positive (negative) stance implies that future inflation will fall below (rise above) the average inflation rate of the past 18 months in

Figure 4
Monetary policy stance, inflation, and GDP growth

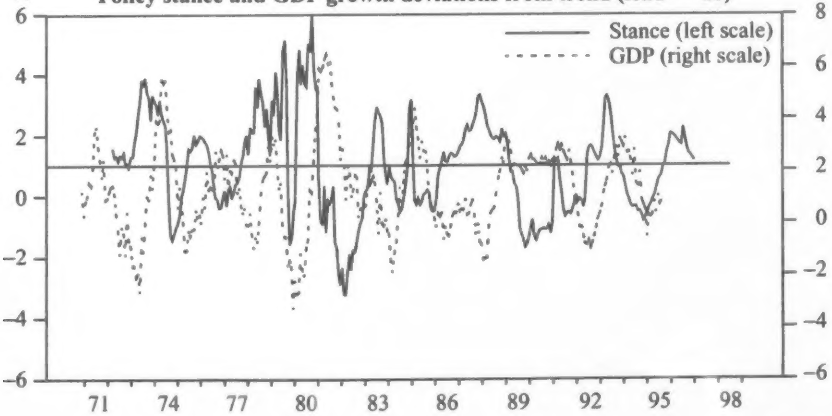
Monetary policy stance



Policy stance and inflation deviations from trend (lead = 24)



Policy stance and GDP growth deviations from trend (lead = 18)



the absence of the other shocks. The derived stance is plotted in the top panel of Figure 4.

In the middle and bottom panels of Figure 4 we also compare the stance with actual inflation and GDP growth with a 24-month lead and an 18-month lead. Inflation and GDP growth are also calculated as the deviations from their 18-month moving averages. A tight (easy) policy stance should be followed by a decrease (increase) in inflation if no other demand or supply shocks occur, or if monetary policy shocks dominate other shocks. The middle panel of Figure 4 shows that this relationship between the stance and inflation generally holds, most notably for the period 1986–94. When policy was expansionary in 1986 and the first half of 1987, inflation rose above its past trend. When the Bank started its anti-inflationary policy in 1988 and the policy stance became tighter than its past average, inflation decreased to a level consistent with the Bank's inflation-control targets. During the 1990–91 recession the stance was below its past trend to stimulate aggregate demand, and inflation stayed around its own trend or slightly higher in 1994 and 1995.

Similarly, a tight (easy) policy stance should be followed by a decrease (increase) in output growth. The bottom panel of Figure 4 shows that this relationship between stance and output growth also generally holds, notably during the following tight-policy periods: 1973, 1976–77, 1979–82, 1984, 1986, 1988–89, and 1994–95. This implies that monetary policy plays an important role in affecting short-run aggregate demand in these periods.

These graphs should be interpreted with caution, since price level and output are determined by the interaction of aggregate demand and aggregate supply. So far, we have considered only the influence of monetary policy on inflation. Other demand shocks, such as government-spending shocks, may also influence aggregate demand and hence inflation. Supply shocks, such as commodity-price shocks and technological innovations, can also affect inflation.

4.5 Demand-shock dominance or supply-shock dominance

To better understand the effects of monetary policy on inflation and output growth, we examine the historical co-movements of inflation and output growth. In each year the economy is subject to a variety of shocks—broadly speaking, demand shocks and supply shocks. By looking at the co-movements of inflation and output growth, we may be able to identify whether the economy in a particular year is dominated by demand shocks (positive co-movement) or supply shocks (negative co-movement). For those years that are dominated by demand shocks, we examine whether monetary policy stance can account for the co-movements of inflation and output growth.

In Table 2 we report the stance indices from 1974 to 1998 and 1-year changes in inflation and output growth for each year from 1975 to 1998. The integers in column 2 are the stance normalized to a scale of –2 to 2: –2 to –1 denotes "very loose" to "mildly loose," 0 denotes "neutral," 1 to 2 denotes "mildly tight" to "very tight."[18] The 1-year changes in inflation and GDP growth are reported in columns 3 and 4. In column 5, each year is labelled as demand-shock (D)- or supply-shock (S)-dominated according to the co-movements of inflation and output growth. The + and – signs denote positive and negative shocks. In any given year, if inflation and output growth move in the same direction, the year is considered to be demand-shock-dominated; otherwise it is considered to be supply-shock-dominated. A positive (negative) demand or supply shock corresponds to an increase (decrease) in output growth.

In the 24-year period from 1974 to 1998, we find that demand shocks have dominated for about 13 years. Monetary policy can explain 9 of them (assuming monetary policy affects the economy with a 1-year lag): 1975, 1978, 1982, 1985, 1990–91, 1993, and 1996–97. For example, when policy was very tight in 1989 (an index of 2), both inflation and output growth fell in 1990. To account for the remaining 4 years, we consider another major demand shock—government-spending shocks (GS). A simple quarterly AR(4) model is estimated for government spending on goods and services over the period. Of these 4 years, 2 can be explained by government-spending shocks—1981 and 1987—leaving only 2 years unexplained—1979 and 1998. This analysis suggests that monetary policy plays an important role in determining inflation and output growth when the economy is not dominated by supply shocks.

Conclusion

In this paper we derive a measure of the stance of monetary policy based on a model that considers three channels of monetary transmission: the interest rate channel, the exchange rate channel, and the money channel. From the impulse-response functions we find that the model can generate dynamic responses that are consistent with the standard views of the monetary

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[18] We normalize the stance by assuming that the stance is normally distributed and dividing the distribution into five regions of equal probability. The regions from left to right are labelled by the integers from –2 to 2. Then we classify the stances according to the region labels. For example, if a stance falls into region 0, then the stance is classified as 0, which implies a neutral policy. The government-spending shocks are also classified according to the same procedure.

Table 2
Numerical presentation of policy stance, 1974 to 1998

	MS	$\pi_t - \pi_{t-12}$	$dy_t - dy_{t-12}$	D or S	GS
1974	2	3.12	−3.45	−S	−2
1975	−2	−0.18	−2.42	−D	−2
1976	1	−2.88	4.63	+S	1
1977	−1	0.33	−2.76	−S	−2
1978	1	0.95	0.29	+D	1
1979	2	0.13	0.74	+D	0
1980	1	0.93	−2.15	−S	−2
1981	2	2.07	1.13	+D	−1
1982	−2	−1.43	−5.99	−D	0
1983	−2	−4.57	5.52	+S	0
1984	1	−1.51	2.97	+S	0
1985	−1	−0.33	−0.42	−D	−2
1986	0	0.22	−2.44	−S	2
1987	−1	0.16	1.16	+D	−1
1988	1	−0.28	0.60	+S	−2
1989	2	0.89	−2.25	−S	−1
1990	1	−0.20	−1.84	−D	−2
1991	−2	−0.91	−1.80	−D	1
1992	−2	−2.28	2.24	+S	1
1993	−2	0.38	1.60	+D	2
1994	0	−0.48	2.04	+S	1
1995	1	0.89	−1.86	−S	2
1996	−2	−0.70	−1.09	−D	2
1997	−1	0.07	2.53	+D	1
1998	1	−0.65	−1.17	−D	0

Notes: Column 2 reports the normalized policy stance (MS) we calculated. The scale −2 to −1 denotes "very loose" to "mildly loose," 0 denotes "neutral," and 1 to 2 denotes "mildly tight" to "very tight." The 1-year changes in inflation are in column 3, and the 1-year changes in GDP growth are in column 4. In column 5 the year is labelled as demand-shock (D)- or supply-shock (S)-dominated according to the co-movements of inflation and output growth. The + and − signs denote positive shocks and negative shocks. Government-spending shocks (GS) reported in column 6 are estimated based on an AR(4) process. The normalized scale −2 to 2 denotes a range from a large positive shock (expansionary fiscal policy) to a large negative shock (contractionary fiscal policy).

transmission mechanism; i.e., following an expansionary policy shock, the interest rate and the term spread decline, output and the price level increase, and the Canadian dollar depreciates relative to the U.S. dollar.

The stance measure derived from the model is broadly consistent with the historical performance of monetary policy with respect to the developments of inflation and output growth. Among the four variables considered in the stance, only the overnight rate plays a significant role. This result is robust across the two subsamples considered. Our results also suggest that, in general, the Bank does not respond vigorously to contemporaneous surprises in the credit market and the exchange rate. This is consistent with the fact that the Bank does not target the exchange rate, but acts only to smooth the change in the exchange rate to avoid disruption to financial markets. We also find that the policy shocks and policy stance are quite consistent with the historical record of inflation and output growth. Finally, the empirical evidence suggests that monetary policy plays an important role in affecting short-term aggregate demand and inflation dynamics.

Parameter instability is always a concern in time-series analysis because of policy regime switches, financial innovations, and other structural changes. In the subsample estimations we observe different parameter estimates and dynamic responses of output and the price level. In the future we will re-examine this issue by considering several non-linear regression models, such as time-varying parameter models (Boivin 1999), smooth transitional regression models (Weiss 1999), and threshold models (Choi 1999). Non-linear analysis is more suited to dealing with parameter instability because, for example, regime shifts can be determined by the data rather than by subjective judgment.

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Discussion

Frank Smets

Introduction

It is a real pleasure to take part in this conference and discuss the paper by Ben Fung and Mingwei Yuan. I have followed the Bank of Canada's conferences for several years now and always very much appreciated the high-calibre, focused, and policy-relevant papers that are presented here (and their paper is no exception to this rule). Moreover, this year's conference has a special focus on money and the role of money in monetary policy, and as you may know, money plays a special role in the monetary policy strategy of the European Central Bank (ECB). In its attempt to maintain price stability, the ECB uses a two-pillar strategy consisting of a prominent role for money in the form of a reference value for growth in M3 and a so-called broadly based assessment of the outlook for price developments and the risks to price stability. We are thus very interested in hearing about the role of money in a somewhat different monetary policy framework such as that of the Bank of Canada.

But back to the Fung and Yuan paper. Let me start by saying that I very much enjoyed reading this paper. It is well written, addresses a very interesting policy issue, and produces some interesting results. I will divide my comments into two parts. In the first part I will focus on the authors' implementation of the Bernanke-Mihov methodology, in particular their choice of policy variables and identification scheme. In the second part I will discuss more generally how to measure the stance of monetary policy (following Blinder's suggestion) and will suggest an alternative VAR methodology for this purpose.

1 Identifying Monetary Policy Shocks

As Fung and Yuan discuss, Bernanke and Mihov (1998) distinguished between policy variables and non-policy variables. Fung and Yuan choose non-policy variables (variables not contemporaneously affected by policy) that are similar to those used in the literature. However, they depart from the literature in, first, their choice of policy variables and, second, their short-run identification scheme to identify the policy shock using the policy variables they have chosen. I will discuss both in turn.

1.1 Choice of policy variables

In addition to using the most commonly used indicator of monetary policy, a policy-controlled interest rate, Fung and Yuan include three other variables: the exchange rate, the term spread between the 3-month rate and the 10-year government bond yield, and the monetary aggregate M1. The importance of the short-term interest rate and the exchange rate for measuring the stance of monetary policy in an open economy is well understood. These two variables are included in the MCI because they reflect the two most important transmission channels of monetary policy in the Canadian economy. This is discussed in Freedman (1994) and Longworth and Poloz (1995), and has also been reflected in the VAR literature, which tries to identify monetary policy shocks in open economies—see, for example, Cushman and Zha (1997) for Canada and Smets and Wouters (1999) for Germany.

A natural question is, Why do Fung and Yuan include the term spread and M1 in the VAR? They give some indication in their introduction, but I think a more extensive discussion is appropriate. In particular, there are two reasons why such financial variables may enter a policy reaction function and thus become important in identifying monetary policy shocks. One reason is that these variables play a role in the transmission mechanism. A second reason is that they contain information about future output and inflation, information that is not captured by the other variables.

It is quite important to distinguish between those two reasons in the context of Fung and Yuan's paper because one may argue that if the main reason for responding to a policy variable is its information content, a reason that seems to be implied by some of their introductory discussion, then it is not clear that the policy variable should necessarily be incorporated in a measure of the stance of policy. Such a measure should include only financial variables that play a structural role in the transmission mechanism. For example, if developments in M1 have leading-indicator properties for real growth because agents hold more money in anticipation of stronger growth, then it may be appropriate for the central bank to respond to strong M1 growth by raising short-term interest rates. However, in the absence of a structural role in the transmission mechanism, such a rise in M1 growth should not be treated as an easing of the policy stance. This example shows that identifying the short-term reaction function of monetary policy does not necessarily imply that one has identified the appropriate weights on the various variables to measure the stance of policy.

More discussion of the transmission channels through M1 and the term spread would be useful because it would give an indication of the appropriate weight on these indicators in the stance measure. For example, what is the evidence of a direct-money channel that Fung and Yuan (page 234) discuss, and what form does that channel take? Does it have a real balance effect? Interestingly, McCallum (1999) calibrated the real balance effect in an otherwise-standard real business cycle model and found that for conventional parameters this effect should be quite small. Or do the authors have a bank-credit channel in mind? If so, what is the evidence for such a channel in Canada? Research presented at a previous Bank of Canada conference suggests that there is little evidence of such a narrow bank-lending channel in Canada.

Similarly, concerning the term spread, what channel (in addition to that working through the short-term rate) do Fung and Yuan have in mind? For example, do they think that changes in the risk premium on Canadian government bonds will spill over into risk premiums for the corporate sector and therefore affect spending? If this is the transmission channel envisaged, then one would expect that a fall in the term spread driven by a rise in the long-term rate would have a negative impact on economic activity and that the central bank would respond by lowering rates in response to an unexpected steepening of the term structure.

1.2 Identifying the policy shock

Identifying a monetary policy shock from a system of four highly interdependent financial variables is not easy. In equations (10) through (13), Fung and Yuan show the short-run model. Apart from the restriction that money-demand shocks have no impact on the interest rate set by the Bank of Canada, no obvious restrictions come to mind.[1] Nevertheless, they need three additional restrictions to identify the various money market shocks. They therefore assume that changes to the exchange rate are purely random and are not contemporaneously determined by money-demand, policy, or term-structure shocks.

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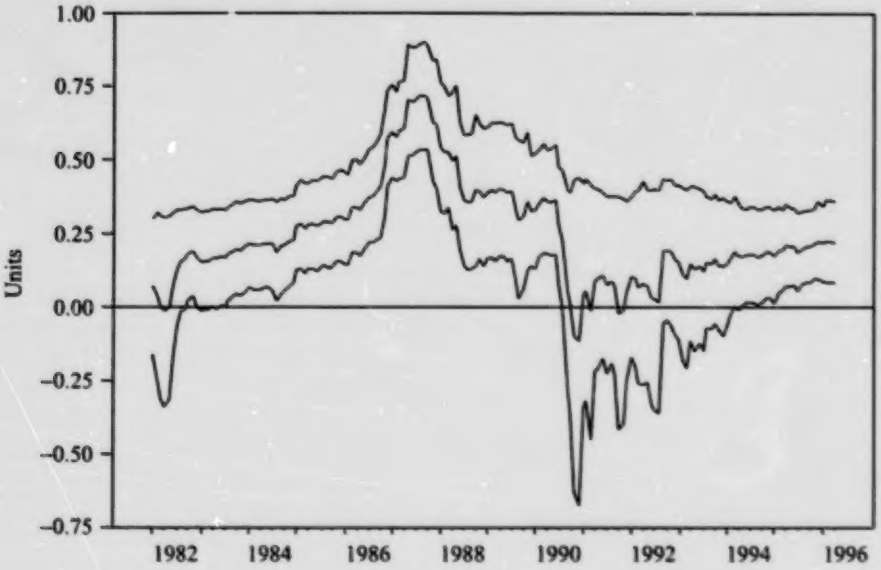
[1] This restriction seems to suggest that there is no structural role for money in the transmission mechanism. Otherwise the central bank would find it optimal to offset such shocks.

Because of the interest rate parity condition, assuming that the term-structure shocks have no direct effect on the exchange rate is clearly unattractive. For example, assume that for some reason the financial markets expect the Bank of Canada to raise rates in the future. This would lead to a contemporaneous steepening of the term structure and an appreciation of the exchange rate. With this shock the correlation between the term spread and the altered exchange rate would be the opposite of the one following an exchange rate shock. Even more importantly, current policy decisions would likely affect the current exchange rate through the interest rate parity condition. If such shocks occur, then imposing zero restrictions would result in a misspecification of the model and implicitly affect the weights on the various components of the policy shock. This misspecification may explain why the estimated weight on the exchange rate is insignificant and economically small. One advantage of having overidentified restrictions (as in Bernanke and Mihov 1998) is that the specification can be tested. However, without additional instruments it is difficult to see what alternative restrictions would be reasonable.

Most of the VAR literature has focused on trying to find such suitable instrument variables. Under the assumption that the monetary authority does not directly respond to the foreign interest rate, one commonly used instrument is the foreign interest rate innovation (Bernanke and Mihov 1997 and Clarida and Gertler 1997). Cushman and Zha (1997) applied the Sims and Zha (1998) identification scheme to an open-economy VAR for Canada. They assumed that the central bank only responds to current financial variables (such as the exchange rate) that are directly observed; the central bank does not react to current output and prices, which are only observed with a lag. However, the exchange rate is affected by all variables in the VAR, including current output and prices. Under these assumptions, changes in current output and prices can be used as instruments to estimate the policy reaction to the exchange rate. Finally, a number of authors, including Smets and Wouters (1999), have argued that foreign exchange rates can be used to identify exchange rate shocks. In some unpublished work for Canada I have used the DM/US$ and ¥/US$ bilateral exchange rates as instruments and found a quite significant reaction of monetary policy to exchange rate variables. This is, of course, consistent with the use of an MCI as an operational target at the Bank of Canada. At the same time, given the change in policy regime and the fact that the MCI was only used since the end of the 1980s, one would expect the estimated weight varies over time, and this is indeed the case. Figure 1 depicts the estimated MCI weight with a 95 per cent confidence interval (using a moving window of

Figure 1
Estimated MCI weight, Canada, 10-year moving window, 1982 to 1996, 95 per cent confidence interval



10 years) in an otherwise conventional VAR that includes real growth, inflation, a nominal trade-weighted exchange rate, and a short-term nominal interest rate.

2 The Stance of Monetary Policy

Fung and Yuan refer to Blinder (1998) when defining the stance of monetary policy as a quantitative measure of whether policy is too tight (restrictive), neutral, or too loose (accommodative) relative to the objective of keeping inflation constant. As they discuss, having a good stance measure is important because it allows the central bank to assess its policy's impact on the objective of price stability. Everything else being equal, a restrictive policy stance, when maintained, will eventually lead to deflation, whereas an accommodative policy stance will eventually lead to inflation.

The big question is, What is a neutral stance? Fung and Yuan provide two different policy stance measures that correspond to two different notions of the neutral stance and show their relationship with future price developments. The first measure, discussed in their section 4.3, is an 18-month moving average of the monetary policy shock. This measure basically compares actual policy with the central bank's average reaction function over the estimation period. Although such information is useful and gives an indication of the (limited, it is to be hoped) contribution of unexpected monetary policy changes to the economy's volatility, this measure is not the one Blinder (1998) proposed, as I will discuss below. Moreover, given the inflation performance over the estimation period, it is clear that whatever the central bank's average reaction function was over this period, it was not appropriate with respect to the goal of price stability as currently defined by the Bank of Canada.

I have three further remarks on this particular measure. First, it surprises me that the admittedly smoothed measures of monetary policy deviations are so persistent. If these shocks are independent and identically distributed as they should be, then taking a moving average should quickly bring them to zero. Second, this analysis depends very much on the stability of the reaction function over the estimation period. As Fung and Yuan at various stages emphasize that the monetary policy regime has changed over this period, it would be interesting to see whether the analysis, now based on the whole sample, holds true for the shorter samples. In fact, the shifts in policy regime may well explain why the shocks are relatively persistent. Third, in their Figure 3 the authors should use a historical decomposition of inflation using the estimated VAR. Such a historical decomposition gives a direct measure of the estimated contribution of the policy shocks to the developments in inflation—see, for example, Gerlach and Smets (1995).

The second measure of the policy stance is discussed in Fung and Yuan's sections 4.4 and 4.5. In these sections they follow Bernanke and Mihov (1998), applying the estimated weights in the identification procedure of the policy shock to the endogenous policy variables and normalizing the stance at each date by subtracting from it an 18-month moving average of its own past values. This procedure defines the average stance in the last 18 months as the benchmark of neutral policy. I have two remarks about this. First, this choice is obviously arbitrary, and it would be useful to discuss a bit further why an 18-month average was chosen and to see whether different windows produce different results. Second, it is not clear why this measure should be related to future output and inflation. The association between this measure and future output and inflation depends on the source of the shock that drives the changes in the financial variables. In interpreting this measure, Fung and Yuan therefore face the same problem as the one they identify in their introduction with using the MCI as a measure of the policy stance.

In sum, both measures are problematic because they do not use a satisfactory definition of the neutral stance. To solve this problem one needs to define the long-run equilibrium values of the various components in the measure of policy stance. Here it is useful to review what Blinder had in mind with his definition of the neutral stance.

In the context of a relatively closed economy, Blinder (1998, 32) noted that

> at any point in time, given all the standard determinants of aggregate demand—including fiscal policy, the exchange rate, and the spending propensities of consumers and investors—the economy has some *steady-state IS curve* [author's italics]. By this I mean the IS curve that will prevail once all the lags have worked themselves out, and provided all random shocks are set to zero.

He then defined "the neutral real interest rate . . . . as the interest rate that equates GDP along this steady-state IS curve to potential GDP . . . ." As a result, "the neutral real interest rate is not a fixed number. It depends, among other things, on fiscal policy and the exchange rate; and it is sensitive to other *permanent* [my italics] (though not temporary) IS shocks." The big problem when empirically implementing the Blinder definition is that one needs to distinguish between permanent and temporary shocks to the IS curve. In a way, Blinder used the steady-state IS curve to filter out transitory fluctuations in demand and focus on longer run factors. Durable IS shocks do change the neutral real interest rate, but temporary shocks do not.

This emphasis on the need to distinguish between temporary and permanent shocks to the real interest rate suggests that an alternative VAR methodology, based on long-run identification restrictions, may be more fruitful for uncovering a measure of the policy stance. Using the common-trends methodology of King et al. (1991), we could define the neutral real interest rate as that part of the interest rate that is driven by the stochastic trends in the model. Obviously, for an open economy such as Canada the model would need to be extended in order to also uncover the long-run trends that govern the equilibrium real exchange rate, as is done, for example, in Clarida and Galí (1994). The measure of monetary policy stance could then be defined as the deviation of the weighted average of actual policy variables from their long-run value.

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Discussion

Sharon Kozicki

What is the current stance of monetary policy? The answer is an important piece of information for those who craft monetary policy. When assessing whether current policy should be adjusted, policy-makers like to have reliable benchmarks. A stance measure that indicates whether current policy is tight, neutral, or loose would be very useful. Fung and Yuan set out to provide such a benchmark for Canada in the form of a single-dimensioned variable that measures the stance of monetary policy relative to an objective of keeping inflation constant.[1]

Fung and Yuan construct their stance measure as a linear combination of observable variables and normalize it so that a stance measure of 0 means a neutral policy. In my comments I will divide their procedure into two steps. In the first step, Fung and Yuan decide what variables to include in the policy block and estimate the weights to be applied to those variables. In the second step, they assess what level of the stance measure, before normalization, corresponds to neutral policy.

I will comment on Fung and Yuan's procedures and offer my interpretations of their results. I have two main observations. Interestingly, the empirical results suggest that the overnight rate summarizes *all* relevant information about the stance of monetary policy in Canada from a candidate list of variables including M1, the term spread, the overnight rate, and the exchange rate. However, I don't think that Fung and Yuan's empirical representation of neutral monetary policy corresponds to their conceptual definition of it. Consequently, although the Fung-Yuan stance measure may provide information about relative ease or tightness of policy in Canada, I don't think it quantifies policy in an absolute sense as tight, neutral, or easy.

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[1] Fung and Yuan define their measure of the stance of monetary policy relative to an objective of keeping inflation constant. According to their definition the stance is considered neutral if it is consistent with constant inflation in the medium run. Alternative definitions are possible. For instance, if a central bank is targeting inflation, then an alternative definition of the stance could be made relative to the central bank's target for inflation or to the midpoint of the central bank's target band for inflation. One advantage of the definition Fung and Yuan choose is that it can be applied in situations where inflation targets are not announced.

1 Variables and Weights

My first set of comments addresses issues related to policy-block variables and weights. Fung and Yuan follow the VAR-based approach of Bernanke and Mihov (1998) to estimate weights to be used in their quantitative measure of the stance of monetary policy in Canada. In the Bernanke-Mihov approach the stance is defined as an unobserved variable that is constructed as a linear combination of policy-block variables. The weights used in the linear combination depend on the identifying assumptions and structural VAR techniques that are used to recover structural shocks in the policy block—different assumptions could lead to different weights. I will comment briefly on the policy-block variables, the identification of structural shocks, and the interpretation of the policy stance measure (before normalization).

1.1 The policy block

The policy block contains a set of variables that are potentially useful as indicators of the stance of monetary policy. Fung and Yuan note that the central bank might not have complete control over the policy-block variables, because such variables are also influenced by other shocks, but the bank might have significant influence on these variables in the current period. The literature provides a long list of candidate variables that may provide information on the stance of monetary policy. The MCI, measures of the exchange rate, and short-maturity interest rates are obvious candidates for Canada. In the United States the federal funds rate is frequently used in empirical studies as an indicator of policy stance. Variations on these themes include real short-maturity interest rates and spreads between long- and short-maturity rates. Measures of money and reserves are other obvious candidates. The four variables that Fung and Yuan include in their policy block are real M1, the term spread, the overnight rate, and the exchange rate.

Fung and Yuan define the stance of monetary policy as a linear combination of these four variables, normalized by a quantitative measure of neutral. Is this reasonable? Perhaps not, according to Fung and Yuan themselves. In their introduction they note that the MCI can be interpreted as a measure of the ease or tightness in monetary conditions relative to a base period, but they criticize interpreting the MCI as a stance measure because the MCI reflects non-policy-related changes in the interest rate and exchange rate. In their words, "the stance of monetary policy should capture only central bank actions" (page 234). But does the newly proposed definition of the stance satisfy this condition? Because the proposed definition also may reflect non-policy-related changes in money, interest rates, and the exchange rate, it may not satisfy this condition. However, this concern may not be problematic, given the specific weight estimates in the paper and my discussion below (section 1.3).

1.2 Identifying structural shocks

Are the identifying assumptions reasonable? This is a standard issue when structural VAR techniques are used. The proposed stance measure is a weighted combination of policy-block variables. Weights depend on identifying assumptions used to recover structural shocks in the policy block; different assumptions could result in different weights. Consequently, the results in their paper and my comments are contingent on the identifying assumptions that Fung and Yuan have made.

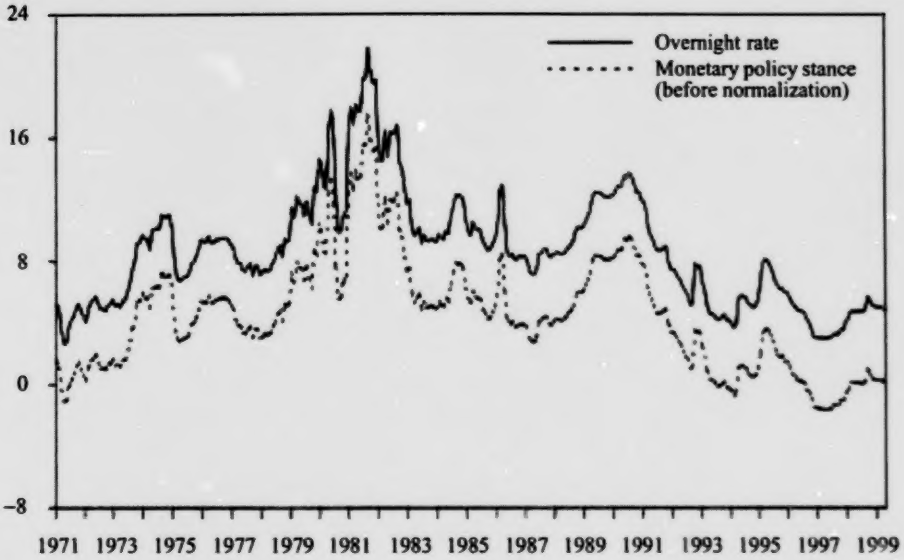
1.3 Policy stance versus the overnight rate

Do estimated weights provide any insight into the policy stance measure? Standard errors of estimated weights suggest that only the weight on the overnight rate is significantly different from 0. Furthermore, the estimated weight on the overnight rate is not significantly different from 1. Although Fung and Yuan did not examine it, I would be interested in knowing whether the joint null hypothesis H_0: $w_M = w_{TS} = w_{PFX} = 0, w_{RON} = 1$ would be rejected. If it were not rejected, then the empirical results would suggest that the overnight rate summarizes *all* the statistically significant information about the stance of Canada's monetary policy from a candidate list of variables including M1, the term spread, the overnight rate, and the exchange rate.

To graphically examine the extent to which the overnight rate summarizes the relevant information about the stance of Canada's monetary policy, I have prepared two figures. Figure 1 shows the overnight rate and the monetary policy stance measure before normalization. The not-normalized stance measure was constructed as

$$w_M\, M + w_{TS}\, TS + w_{RON}\, RON + w_{PFX}\, PFX,$$

Figure 1
Monetary policy stance (before normalization) and the overnight rate



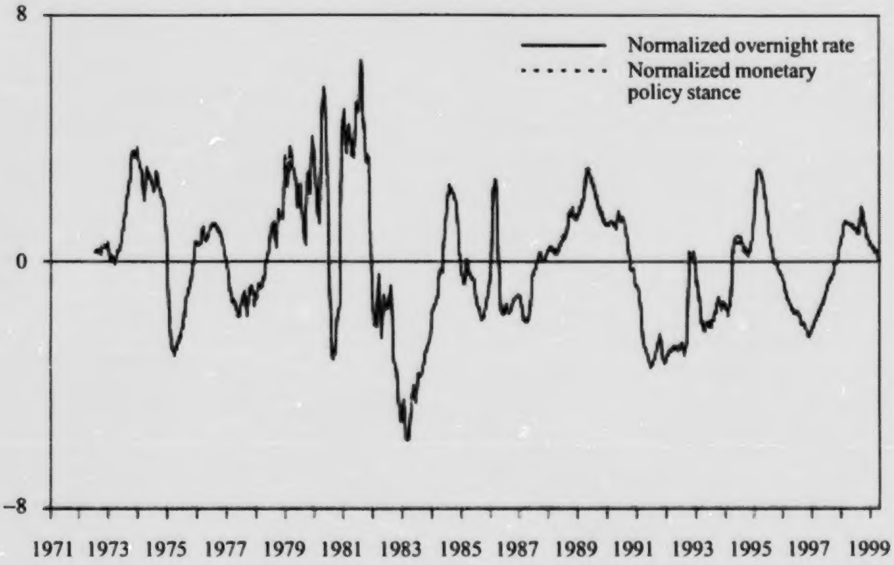
using Fung and Yuan's full-sample estimated weights and data for the natural logarithm of real M1 (*M*), the term spread (*TS*), the overnight rate (*RON*), and the natural logarithm of the Can\$/US\$ exchange rate (*PFX*). The not-normalized stance measure differs from the overnight rate primarily by a level shift. Variation in the two series is remarkably similar.

Figure 2 shows the normalized monetary policy stance measure and a normalized version of the overnight rate. Each series is normalized by subtracting from the not-normalized version of the series an 18-month moving average of its own past values. The two series are almost identical. These results suggest that Fung and Yuan (page 249) understate their conclusions when they find that "the overnight rate contains the most significant amount of information about policy stance." In fact, it appears that the overnight rate contains *all* the policy block's information about policy stance.

2 Quantifying Neutral Policy

My second set of comments addresses the procedure Fung and Yuan use to quantify neutral policy (i.e., to normalize the stance measure). Without normalization the stance measure provides some information on the *relative*

Figure 2
Normalized monetary policy stance and overnight rate



stance of policy, but does a poor job of describing its *absolute* stance. For instance, a specific value of the overnight rate might represent "easy" policy when expected inflation is high, but "tight" policy when expected inflation is low (Bernanke and Blinder 1992). The not-normalized stance measure may help establish whether policy is tighter or easier than in a not-distant period when inflation expectations were similar, but it isn't very helpful in establishing whether policy in any given period is tight or easy.

My main criticism lies with Fung and Yuan's empirical definition of neutral monetary policy. I don't think that their empirical representation corresponds to their conceptual definition. Empirically, neutral monetary policy is defined as an 18-month moving average of the not-normalized stance measure.[2] Conceptually a neutral monetary policy stance is defined as consistent with constant inflation in the medium run.[3]

Fung and Yuan's stance measure is normalized so that 0 is the benchmark of neutral monetary policy. Since their normalization procedure subtracts an 18-month moving average of the not-normalized stance measure from itself, they are defining a neutral stance as the 18-month moving average. For this to be consistent with their conceptual definition of neutral, they are assuming that average policy over every 18-month period is neutral and consistent with constant inflation in the medium run.

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[2] Bernanke and Mihov normalized their policy stance measure by subtracting from it a 36-month moving average of its own past values. Consequently, similar concerns to those raised in this section may apply to Bernanke and Mihov's normalization.

[3] I prefer the conceptual definition of neutral to the empirical definition. In general, I don't support using moving averages as representative of a neutral benchmark for normalization.

I believe that this assumption is unreasonable. Presumably, if average policy were consistent with constant inflation over a moderate horizon, then roughly stable inflation rates should be observed. However, inflation rates moved considerably in 1971–82 and 1991–92. Average policy over the 18-month periods before and during most of these intervals was likely not consistent with constant inflation. In contrast, inflation rates were relatively stable from 1983 to 1990 and from 1992 to 1999. It might be reasonable to assume that policy was, on average, consistent with constant inflation over a portion of these two subsamples. This might explain why, as the middle panel of Fung and Yuan's Figure 4 shows, their stance measure seems to provide information on the direction of future inflation movements over the period 1985 to 1990.

Although I disagree with the empirical representation of neutral policy as an 18-month moving average of the not-normalized stance measure, Fung and Yuan's stance measure does resemble other proposed indicators of the stance. Figure 3 (in this paper) compares the normalized overnight rate with the overnight rate, the difference between the term spread and its sample mean, and the difference between the real overnight rate and its sample mean.[4] Fung and Yuan's measure is not included because it is virtually identical to the normalized overnight rate. High-frequency variation in all four series is similar—most likely because the overnight rate, or another short rate, is the dominant source of high-frequency variation in all four series. The lower three measures in the figure have been adjusted in a way to suggest that positive values indicate tight policy and negative values indicate loose policy. Although these three measures are similar, the signals from the series do not always agree. Divergence is greatest in 1972–73, 1982–84, and 1990–92—periods in which the level of inflation changed considerably.

Concluding Comments

Fung and Yuan set out to empirically answer a very important question: What is the stance of monetary policy? I suggest two modifications to their conclusions. First, the empirical results suggest that the overnight rate summarizes *all* relevant information about the stance of monetary policy in

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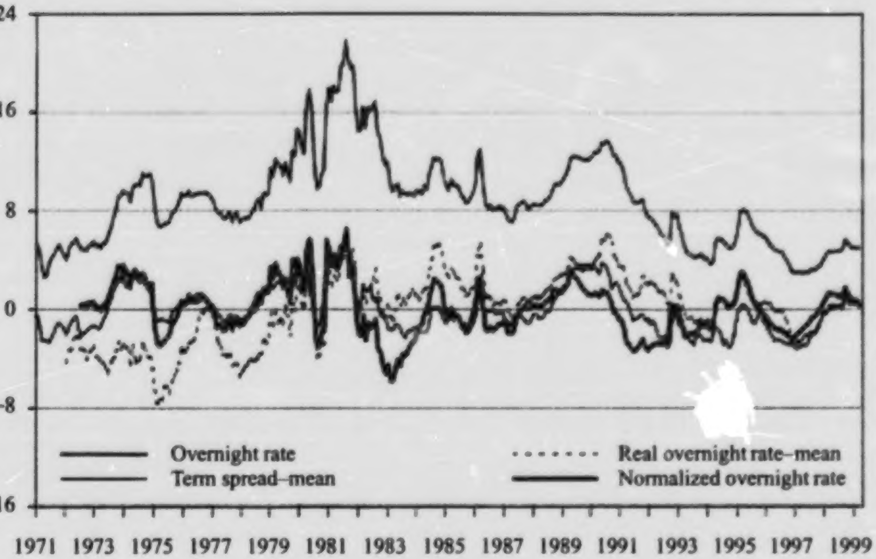
[4] The real overnight rate is constructed as the difference between the overnight rate and inflation over the previous 12 months.

Figure 3
Comparison of measures of the stance of monetary policy



Canada—given the variables they included in the policy block and the assumptions they made to identify structural policy shocks. Second, the proposed stance measure provides information on the relative stance of policy, but it would be premature to claim that the difficulties associated with identifying the absolute stance of policy have been solved.

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General Discussion

Comments by both Frank Smets and Sharon Kozicki had referred to the choice of variables that Ben Fung and Mingwei Yuan consider in the policy block—the overnight rate, M1, the term spread, and the price of foreign exchange. In addressing the issue of the relative information these four financial variables contain, Fung argued that their choice reflects his and Yuan's intention to capture several channels for the transmission mechanism of monetary policy: the interest rate channel, the money channel, the credit channel, and the exchange rate channel.

Responding to the discussants' comments regarding the identification scheme he and Fung use, Yuan noted that by relaxing the restrictions on the weights of the four variables, he and Fung are attempting to relax prior restrictions on these variables. Fung underlined the difficulty of imposing the right restrictions. The model is allowed to decide upon the right identification scheme so that the authors may use the data as an indicator of the right identifying assumptions.

Fung and Yuan's partial use of Blinder's (1998) approach was another subject discussed by Smets, who had suggested a more complete application of Blinder's methodology. While mentioning that a certain amount of work already in progress at the Bank of Canada is attempting to estimate the neutral interest rate, Yuan noted that the framework they use in their paper allows them to easily capture different types of shocks to the economy, such as technology shocks incorporated in output or price shocks incorporated in the CPI. Isolating this type of shock from monetary policy shocks could yield insights into the transmission mechanism of monetary policy.

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* Prepared by Marilena Ifrim.

Fung and Yuan's finding that the overnight rate contains almost all relevant information about the stance of monetary policy prompted Kozicki to remark that this result should be conditioned on the variables in the policy block and the identifying assumptions. Replying to comments about the relative, as opposed to absolute, character of the proposed measure of the stance of monetary policy, Yuan highlighted the major difficulties still facing analysts in defining neutral policy. However, the usefulness of having a reliable relative stance for monetary policy, especially in a context where a monetary policy regime changes as a result of financial innovations, renders value to their exercise.

Referring to the informational content of the overnight rate, Seamus Hogan was puzzled by Fung and Yuan's conclusion that the overnight rate summarizes 99 per cent of the information relevant to the monetary policy stance. He noted that a stance measure should be zero when monetary policy is neutral, and a given deviation should have the same meaning in any given period. Reminding the audience that the MCI is a difficult concept to use because the equilibrium exchange rate is so uncertain and variable, he pointed out that the MCI does not have the same meaning in any given period. Hogan also said that the finding about the overnight rate may indicate difficulties in identifying the neutral policy level of the other three financial variables rather than a lack of information (relevant to the policy stance) within these variables.

In addressing these comments, Yuan referred to the conceptual difference between the MCI and the monetary policy stance, arguing that the stance is solely controlled by the monetary authority, whereas the MCI reflects an overall condition of the economy. He emphasized that the overnight rate's dominance is an empirical result and that their method does not restrict a priori other variables' influence.

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Financial Intermediation, Beliefs, and the Transmission Mechanism

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Robert Amano, Scott Hendry, and Guang-Jia Zhang

Introduction

A growing body of literature emphasizes the role of financial intermediaries in the economy. We have chosen to focus on the significance of liquid assets in the behavioural problem of financial intermediaries.[1] To this end, we extend a standard limited-participation model to incorporate: (i) financial intermediaries that optimize profits by allocating funds among longer-term loans and shorter-term liquid assets; and (ii) asymmetric information between private banks and the monetary authority. The interaction of the two factors allows us to capture episodes in which the intent of monetary policy is less than transparent to private agents. In this respect, our work is not a general explanation of the monetary transmission mechanism; instead, it emphasizes the importance of financial intermediaries in the monetary transmission mechanism when the direction of monetary policy or the general state of the economy is unclear.

Our findings show that an expansionary policy may have smaller but more protracted effects on an economy when the public does not clearly understand the intent of a monetary policy action, and when financial intermediaries are in a position to choose between longer-term lending and

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[1] For Canadian chartered banks, liquid assets comprise, on average, a significant 12 per cent of Canadian dollar assets.

* We thank Kevin Moran for his numerous discussions with us, and Walter Engert and Jack Selody for their discussion and continual support. We are also grateful to Jim Armstrong, Paul Gomme, Sylvain Leduc, and the seminar participants at the Bank of Canada for useful comments.

shorter-term investment in liquid assets. When, in the event of a monetary easing, financial intermediaries invest in liquid assets, there is less positive real impact and less inflationary pressure in the commodity market, because that liquidity is not being lent to firms. Banks release new liquidity into the lending market only when they are certain that the central bank will not withdraw the injected liquidity from the system in the near future. This monetary effect is not caused by an asymmetric information set-up between lenders and borrowers, as described in Bernanke, Gertler, and Gilchrist (1998). Instead, it is driven by the financial intermediaries' misinterpreting monetary policy. Misinterpreting the stance and direction of monetary policy can occur for many reasons, including low policy credibility, infrequent policy shocks, or an environment with other financial market shocks present, which makes it more difficult for financial institutions to understand the stance and direction of monetary policy.

Our findings also suggest that monetary policy actions have variable effects. When the true intent of policy is clear, the transmission lag between the policy action and the economy is relatively short. When the direction of monetary policy is unclear, we find that the effect of monetary policy on output and inflation is more muted, and occurs with a longer lag.

1 The Structure of the Model

The model's basic structure uses the standard limited-participation framework similar to that found in Lucas (1990), Fuerst (1992), and Christiano and Eichenbaum (1992). We modified the model to permit financial intermediaries to maximize profits by allocating resources between short-term liquid assets and longer-term lending when private agents are unclear about the central bank's policy intentions.

One period in the model is assumed to represent a quarter, and is divided into two subperiods. Unlike a standard limited-participation model, there can be two money-growth-rate shocks each quarter, one occurring before lending decisions are made and the other hitting the economy after lending decisions are made. To offset possible costs associated with the second shock, intermediaries hold liquid assets as a buffer stock. Given certain shock processes and information frictions, the amount of liquid assets intermediaries hold can have important effects on the monetary policy transmission mechanism.

All real variables and prices are determined during the first subperiod, when only the first shock is known. Banks are assumed to be able to adjust only their liquid-asset holdings after the second shock occurs. After this, the quarter ends in the usual fashion: loans are repaid, firms and banks pay out dividends, and households select their deposit levels for the next period. This set-up allows liquid assets to be adjusted more often than production decisions.

1.1 The central bank

Monetary policy is conducted in this model through the setting of the money-growth rate. A change in money growth may occur for either policy-related or non-policy-related reasons. Policy-related changes approximate the reaction function, the targeting rule of the central bank, or both. In the model, these changes are considered to be relatively more persistent. Non-policy shocks to the money-growth rate represent such things as neutralized government transactions, random errors, and reactions to transitory-level shocks in the rest of the economy. These changes occur more frequently than the policy-related changes. The distinction between the two types of actions is important; they follow separate processes, causing private agents to respond very differently to each shock. Specifically, let X_t be the total money transfer to banks in period t. According to our assumption, X_t can be decomposed as follows:

$$X_t = X_t^p + X_t^{np}, \tag{1}$$

into a policy component, X_t^p, or a non-policy component, x_t^{np}. We assume that the central bank has full information, but the public observes only x_t. The growth rate of the policy component is assumed to be a positive first-order autoregressive process (AR[1]), so when the central bank conducts a policy action it tends to do so persistently. In contrast, the non-policy component of money growth is given by a negative moving average (MA) process, so any change will be reversed over the next few subperiods. More detail on the parameterization of these processes is provided in the section on calibration.

We assume that the central bank intervenes twice in a given time period to model the characteristic that central banks can generally revise their policy decisions more often than firms can adjust their production plans. Therefore, the policy-shock and non-policy-shock components can be decomposed further into two subperiod values, viz.,

$$X_t^p = X_{1t}^p + X_{2t}^p \tag{2}$$

and

$$X_t^{np} = X_{1t}^{np} + X_{2t}^{np}, \tag{3}$$

where X_{it}^j represents the component $j = \{p, np\}$ money transfer in subperiod $i = \{1, 2\}$ of period t.

1.2 Commercial banks

Financial intermediaries maximize profits by choosing the optimal mix of longer-term lending to firms and shorter-term investment in liquid assets. Lending to firms is considered productive intermediation, because the borrowers of the funds produce real goods. Investment in liquid assets is considered non-productive, because this activity does not produce real goods. Consequently, these liquid assets may be thought of as deposits at the central bank or purchases of government debt. Domestic corporate paper should not be counted as liquid assets, because it represents a method other than direct lending of transferring monetary injections to the firms in the period of the injection.[2]

In our model economy, banks combine deposits from households, N_t, with an initial transfer from the central bank, X_{1t}, make loans to firms, B_t, and invest in net liquid assets of D_{1t}.[3] After observing the first policy shock of period t, commercial banks make lending decisions based on their assessment of the breakdown of X_{1t} into X_{1t}^{p} and X_{1t}^{np}, as well as the forecasts of these components. The second subperiod money transfer, X_{2t}, occurs after lending decisions for period t are made. We assume that loans are not callable or that there is some cost making it prohibitively expensive to do so. Consequently, banks can adjust liquid-asset holdings only after seeing X_{2t}, so that monetary transfers received in the second subperiod are used to increase liquid assets or decrease short-term borrowing.

More formally, commercial banks maximize profits, based on the information set $\Omega_{1t} = \{\Omega_{2t-1}, X_{1t}\}$ in the first half of period t,[4] by allocating funds between liquid assets and loans to firms; that is:

$$\max_{B_t, D_{1t}} \sum_{t=0}^{\infty} \beta^t \lambda_t \pi_t^b$$

$$= \max_{B_t, D_{1t}} E_0\left[\sum_{t=0}^{\infty} \beta^t \lambda_t \{R_t^l B_t + [R^g(R_t^l, D_{2t}) \cdot D_{2t} | \Omega_{1t}] - R_t^d N_t\}\right] \quad (4)$$

subject to

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[2] However, liquid assets could represent purchases of foreign short-term corporate paper, provided there are no significant feedback effects from added production in the foreign economy.

[3] D_{1t} is referred to as net liquid assets, because it can be either positive (short-term lending or deposits with the central bank) or negative (short-term borrowing from the central bank).

[4] $\Omega_{2t} = \{\Omega_{1t}, X_{2t}\} = \{\ldots, X_{1t-1}, X_{2t-1}, X_{1t}, X_{2t}\}$ is the information set covering the complete history of money growth until the end of the second subperiod of period t.

$$N_t + X_{1t} = B_t + D_{1t}, \tag{5}$$

$$D_{1t} + E_t[X_{2t}|\Omega_{1t}] = E_t[D_{2t}|\Omega_{1t}]. \tag{6}$$

Banks earn an interest rate of R_t^l on lending to firms and a return, R_t^g, on end-of-period holdings of liquid assets, D_{2t}. The holding period of D_{1t} is assumed to be short enough that no return is earned. Equation (5) represents the beginning-of-period cash-in-advance (CIA) constraint for banks, and equation (6) represents the banks' expected CIA constraint for the beginning of the second subperiod. Any monetary injection received at this time cannot be lent out, but can be used to increase the banks' net liquid asset position.

The rate of return on liquid assets is assumed to be greater than R_t^l if financial intermediaries are net borrowers over the period $(D_{2t} < 0)$ and smaller than R_t^l if banks are net lenders $(D_{2t} > 0)$. If intermediaries end the period with deposits at the central bank $(D_{2t} > 0)$, then they earn some return, $R_t^g < R_t^d$, which is less than the loan rate. On the other hand, if intermediaries end period t having borrowed from the central bank $(D_{2t} < 0)$, then they must pay a penalty rate, $R_t^g < R_t^l$, that is above the rate paid on households' deposits. This set-up ensures that banks will hold an optimal level of precautionary liquid assets. Therefore, R^g is a step function, which can be approximated by the continuous function[5]

$$R_t^g = R_t^l - \kappa D_{2t}^{\frac{1}{3}}, \tag{7}$$

where $\kappa > 0$.

The first-order condition associated with the above problem is

$$E_t\left\{\lambda_t(N_t + X_{1t} + X_{2t} - B_t)^{\frac{1}{3}}\middle|\Omega_{1t}\right\} = 0. \tag{8}$$

This implies banks will invest in initial liquid-asset holdings D_{1t} until their expected holdings for the entire period are 0. This is optimal, because, for financial intermediaries, it is more profitable to lend out their funds than to hold them in the form of liquid assets. If banks believe that there will be an expansionary monetary shock in the second subperiod, they will run down their liquid assets, by borrowing from the central bank, in order to lend more than their initial cash holdings of $N_t + N_{1t}$. If banks, on the other hand, predict a contraction, they will reduce lending to firms and invest instead in liquid assets to offset the expected shock.

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[5] The model solution, except for R_t^g, does not depend on the parameters of the R_t^g function in (7). They determine the size of the step in the R_t^g function and do not change the desire of banks to target $D_{2t} = 0$ over the period. The banks wish to avoid all penalties, whether small or large. It would be worthwhile to examine a model with a central bank that conducts policy by temporarily changing the mean of the R_t^g function. This would induce banks to adjust their liquid assets in response to a policy change in their expected returns.

1.3 Firms

We assume that firms are perfectly competitive. They borrow funds from commercial banks to finance their wage bill and rent capital from the capital market. These firms, as price takers, maximize profit, π_t, by choosing the optimal amount of capital, k_t, and labour, l_t, based on the same information set as commercial banks. That is,

$$\max_{k_t,\, l_t} E_0 \sum_{t=0}^{\infty} \beta^t \lambda_t \pi_t$$

$$= \max_{k_t,\, l_t} E_0 \left[\sum_{t=0}^{\infty} \beta^t \lambda_t \{ P_t \cdot F(k_t, l_t) - r_t \cdot P_t \cdot k_t - R_t^l \cdot W_t \cdot l_t | \Omega_{1t} \} \right] \quad (9)$$

where P_t is the output price, r_t is the net capital rental rate, and W_t is the nominal wage rate, and production is given by:

$$F(k_t, l_t) = z_t \cdot k_t^{\alpha} \cdot l_t^{1-\alpha}, \quad (10)$$

where z_t represents the level of production technology. The optimal demand for capital and labour satisfies the following marginal conditions:

$$\frac{\partial F(k_t, l_t)}{\partial k_t} = r_t \quad (11)$$

and

$$\frac{\partial F(k_t, l_t)}{\partial l_t} = R_t^l \cdot \frac{W_t}{P_t}. \quad (12)$$

Equation (11) relates firms' marginal product of capital with their real rental rate of capital. Equation (12) implies that the firms' labour demand is negatively related to the real wage rate and their cost of borrowing funds.

1.4 Households

Households enter period t with cash holdings in the goods market of M_t^c and bank deposits of N_t, neither of which can be changed before the end of the period. After observing the initial money transfer in period t, but not the second transfer, households receive wage income by supplying labour to firms. Households make purchases of investment, i_t, and consumption, c_t, out of labour income and cash holdings according to the CIA constraint

$$P_t c_t + P_t i_t = M_t^c + W_t l_t. \tag{13}$$

By the end of period t, households, having all the available information regarding the policy shocks, divide their wealth to be carried forward to period $t+1$ between deposits at the financial intermediaries, N_{t+1}, and cash holdings, M_{t+1}^c. Households make this decision using full information for the period $t, \Omega_{2t} = \{\Omega_{2t-1}, x_{1t}, x_{2t}\}$. This process is summarized in the following budget constraint:

$$N_{t+1} + M_{t+1}^c = R_t^d \cdot N_t + r_t P_t \cdot k_t + \pi_t^b + \pi_t. \tag{14}$$

The right-hand side of (14) represents the households' sources of funds: deposits with interest, capital rental income, and dividend payments from banks and firms.

The law of motion for the capital stock is given by

$$k_{t+1} = (1-\delta)k_t + i_t. \tag{15}$$

Households solve a two-step optimization problem to maximize their lifetime expected utility. In the first subperiod, households choose consumption, labour supply, and investment to maximize

$$max_{\{c_t, l_t, k_{t+1}\}} E_0 \sum_{t=0}^{\infty} \beta^t \{U(c_t, 1-l_t)\}, \tag{16}$$

subject to constraints (13) through (15) based on the information set Ω_{1t}. This problem yields the following marginal conditions for l_t, and k_{t+1}, respectively:

$$U_{1t}(c_t, 1-l_t) \cdot \frac{W_t}{P_t} = U_{2t}(c_t, 1-l_t), \tag{17}$$

$$U_{1t}(c_t, 1-l_t) =$$

$$\beta E_t\{(1-\delta) \cdot U_{1t+1}(c_{t+1}, 1-l_{t+1}) + \lambda_{t+1} P_{t+1} r_{t+1} | \Omega_{1t}\}. \tag{18}$$

In the second subperiod, households choose period $t+1$ deposits and cash holdings to maximize

$$max_{\{M_{t+1}^c, N_{t+1}\}} E_0 \sum_{t=0}^{\infty} \beta^t \{U(c_t, 1-l_t)\}, \tag{19}$$

subject to constraints (13) through (15) based on the information set Ω_{2t}. The marginal conditions for N_{t+1} and M^c_{t+1}, respectively, are given by

$$\lambda_t = \beta E_t\left\{\lambda_{t+1} R^d_{t+1} \middle| \Omega_{2t}\right\}, \tag{20}$$

$$\lambda_t = \beta E_t\left[\frac{U_{1t+1}(c_{t+1}, 1-l_{t+1})}{P_{t+1}} \middle| \Omega_{2t}\right]. \tag{21}$$

The variable, λ_t, is the Lagrangean multiplier associated with the budget constraint (14) and represents the shadow value of adding another dollar to cash holdings in the goods market. Wage and capital rental rates clear the labour and capital markets. The following market-clearing conditions guarantee that commodity and loans markets reach equilibrium:

$$c_t = i_t = F(k_t, l_t), \tag{22}$$

$$N_t + X_{1t} - D_{1t} = W_t l_t. \tag{23}$$

1.5 Information structure and beliefs

As discussed above, changes in the money-growth rate can be separated into policy and non-policy components. Only the monetary authority knows why the money-growth rate has changed. Other agents must form beliefs regarding the proportions of policy and non-policy components in the money-growth rate. We assume that agents extract information from the observable data—the actual money-growth rate—based on a Kalman filter (see Sargent 1987, Hamilton 1994).

By scaling by the money supply at the beginning of the period, M_t, we can convert the monetary transfers into growth rates. Full information is available to private agents about the parameters and the AR and MA order of the policy and non-policy components of the money-growth rate. However, only the central bank has full information about the realizations of the shocks to these processes. Let the policy component of the growth rate in the first and second subperiods of period t be given by:

$$x^p_{1t} = (1-\rho)x + \rho x^p_{2t-1} + \varepsilon^p_{1t}, \tag{24}$$

$$x^p_{2t} = (1-\rho)x + \rho x^p_{1t-1} + \varepsilon^p_{2t}. \tag{25}$$

The *MA*(*N*) non-policy component of the growth rate is given by:

$$x^{np}_{1t} = \varepsilon^{np}_{1t} + b_1 \cdot \varepsilon^{np}_{2t-1} + \ldots + b_N \cdot \varepsilon^{np}_{jt-k} \tag{26}$$

$$x^{np}_{2t} = \varepsilon^{np}_{2t} + b_1 \cdot \varepsilon^{np}_{1t} + \ldots + b_N \cdot \varepsilon^{np}_{lt-m}, \tag{27}$$

where[6]

$$\sum_{i=1}^{N} b_i = -1. \tag{28}$$

This last assumption implies that agents believe any non-policy action will be reversed completely in the subsequent periods. While the parameters of these driving processes are known by all agents, the shock values, ε^{p}_{1t}, ε^{p}_{2t}, ε^{np}_{1t}, and ε^{np}_{2t}, cannot be observed by private agents. In future work, we will examine the implications of uncertainty about the parameters as well.

Following Hamilton (1994), we define the state-space representation of the system as the following two equations:

$$\xi_{t+1} = F_{(N+2)\times(N+2)} \cdot \xi_t + v_{t+1} \tag{29}$$

$$x_{1t} = H' \cdot \xi_t, \tag{30}$$

where, in this case

$$\xi_t = [x^{p}_{1t}, \varepsilon^{np}_{1t}, \varepsilon^{np}_{2t-1}, \ldots, \varepsilon^{np}_{jt-k}]' \tag{31}$$

$$F = \begin{bmatrix} \rho & 0 & 0 & \ldots & 0 & 0 \\ 0 & 0 & 0 & \ldots & 0 & 0 \\ 0 & 1 & 0 & \ldots & 0 & 0 \\ 0 & 0 & 1 & \ldots & 0 & 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots & 0 \\ 0 & 0 & 0 & \ldots & 1 & 0 \end{bmatrix} \tag{32}$$

$$v_{t+1} = [\varepsilon^{p}_{1t+1}, \varepsilon^{np}_{1t+1}, 0, \ldots, 0]' \tag{33}$$

$$H' = [1, 1, b_1, b_2, \ldots, b_N]. \tag{34}$$

A similar set of equations defines the representation for the money-growth rate in the second subperiod of period t, x_{1t}.

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[6] For $N \geq 2$, if N is even, then $j = 1 = 1$ and $k = m = N/2$. If N is odd, then $j = 1 = 2$, $k = (N+1)/2$ and $m = (N-1)/2$.

The projection of the unobservable vector, $\xi_{t+1|t}$, can be written in the following recursive form:

$$\hat{\xi}_{t+1|_t} = F \cdot \hat{\xi}_{t|_{t-1}} + K_t[x_{1t} - H' \cdot \hat{\xi}_{t|_{t-1}}], \tag{35}$$

where

$$K_t = F \cdot P_{t|_{t-1}} \cdot H(H'P_{t|_{t-1}}H)^{-1}, \tag{36}$$

and the mean-squared-error matrix is defined by:

$$P_{t+1|_t} = E[(\xi_{t+1} - \hat{\xi}_{t+1|_t})(\xi_{t+1} - \hat{\xi}_{t+1|_t})']. \tag{37}$$

2 Calibration

The competitive equilibrium consists of equations (5), (6), (8), (11) through (15), (17), (18), and (20) through (23). We solved for the stationary representation of the equilibrium by dividing all the nominal variables by the nominal balance, M_t, and then we calibrated the steady state of the stationary equilibrium to quarterly Canadian data from 1956 to 1998.

Since this paper is about the propagation of monetary shocks, we assumed that there is no technological innovation. The discount factor, β, is set to 0.993, so the annualized quarterly real interest rate is 2.8 per cent, which is approximately the average value observed in the data. Capital is assumed to depreciate at a quarterly rate of 2.5 per cent. Following the standard procedure, the capital share parameter is set to be 0.36. The utility function is assumed to have the following functional form:

$$U(c_t, 1 - l_t) = \frac{[(c_t)^{1-\gamma}(1-l_t)^{\gamma}]^{\psi}}{\psi}. \tag{38}$$

The parameter γ is set to 0.81, so that the representative household spends roughly 0.17 of available time working (total hours worked in Canada divided by the population-hours available based on a 16-hour day). The risk-aversion parameter, ψ, is chosen to be –0.5, which is within the range of other related studies.

Since the average quarterly growth rate for M1 in Canada is 1.1 per cent, we assumed the steady-state money-growth rate in each subperiod to be 0.55 per cent. In the appendixes, we describe both the calibration of the money-growth process and the solution method. Also, we assume that the policy component of the money-growth rate has an AR(1) parameter of $\rho = 0.5$, and that the non-policy component follows an MA(1) process with coefficient $b_1 = -1.0$. Unless otherwise specified, the policy component accounts for 10 per cent of the variance of the total money-growth rate (i.e., $a = var(x_t^p)/var(x_t) = 0.1$). This implies that agents learn about a policy shock slowly.

A low weight on the policy component has several possible interpretations: the central bank has low credibility; policy shocks occur only infrequently; or policy shocks are generally small. The weight on the non-policy component also can be interpreted as the financial institutions' assessment of the probability of needing the current monetary transfer as a cushion against transitory shocks that could occur before the average bank loan matures or generates revenue. For instance, when financial institutions perceive a relatively high risk of financial shocks, they tend to hold larger stocks of financial assets to buffer against these disturbances; this would also lead to a lower value of a. In other words, financial shocks make it more difficult for financial institutions to understand the environment in which they are operating, including the stance and conduct of monetary policy.

We are not arguing that the current calibration of the policy versus non-policy components is realistic for all circumstances. There have been instances when the central bank has clearly signalled its intent. Conversely, there have also been situations when the central bank's intent has not been especially transparent. Our experiments are an attempt to analyze these latter circumstances.

3 The Findings

Our aim in this paper is to explore how financial intermediation helps to propagate an expansionary monetary policy shock when: (i) financial intermediaries are free to choose between loans to firms and investment in short-term liquid assets; and (ii) financial intermediaries and the rest of the public must gradually learn the true intent of monetary policy. The following experiments are designed to serve this purpose.

First, we demonstrate, in a complete-information framework, how our model behaves compared with a standard limited-participation model. Second, given that financial intermediaries can optimize funds between long-term lending and short-term investment, we examine how they propagate a monetary policy shock in cases with and without full information. Third, we show how adding a more realistic financial intermediation sector can improve the performance of the standard model with information frictions. Before presenting the model results, however, we provide some empirical evidence to further stress the importance of financial intermediation in the monetary policy transmission mechanism.

3.1 Canadian data

In Figure 1, we show the results for a monetary policy shock from a six-variable vector autoregression (VAR) with one-standard-deviation confidence bands using Canadian data from 1956 to 1998. A simple Choleski decomposition is used with a variable ordering of: M1, the overnight interest rate, output, the consumer price index (CPI), the ratio of chartered bank liquid assets to total assets, and the exchange rate. Some variation exists in the results for different samples and orderings, but the general flavour of the impulse responses is robust. An exogenous shock to money causes the interest rate to decline for about three quarters before the anticipated inflation effect takes over and the interest rate rises above its starting point. Output increases with a hump-shaped response, peaking about five quarters after the shock. The increase in inflation is more drawn out; the response peaks about 15 quarters after the shock.

Our main concern in this paper is the buildup of liquid assets by chartered banks immediately after an expansionary monetary policy shock. We believe there are two principal reasons for this result. First, an expected decline in interest rates as the shock unwinds itself creates an expectation of capital gains. Second, the nature of the monetary shock is not always apparent to private agents. Financial intermediaries may interpret the easing as a temporary change that the central bank will soon reverse. In response, banks hold more liquid assets as a buffer stock against growing uncertainty. The variation in liquid-asset holdings changes the composition of a financial intermediary's balance sheet, which, in turn, affects its long-term lending to non-financial firms and other profit-making activities. We argue that theoretical models that omit this (and other) aspects of the financial sector may be deficient, and that this omission can have an important impact on the simulated impulse responses.

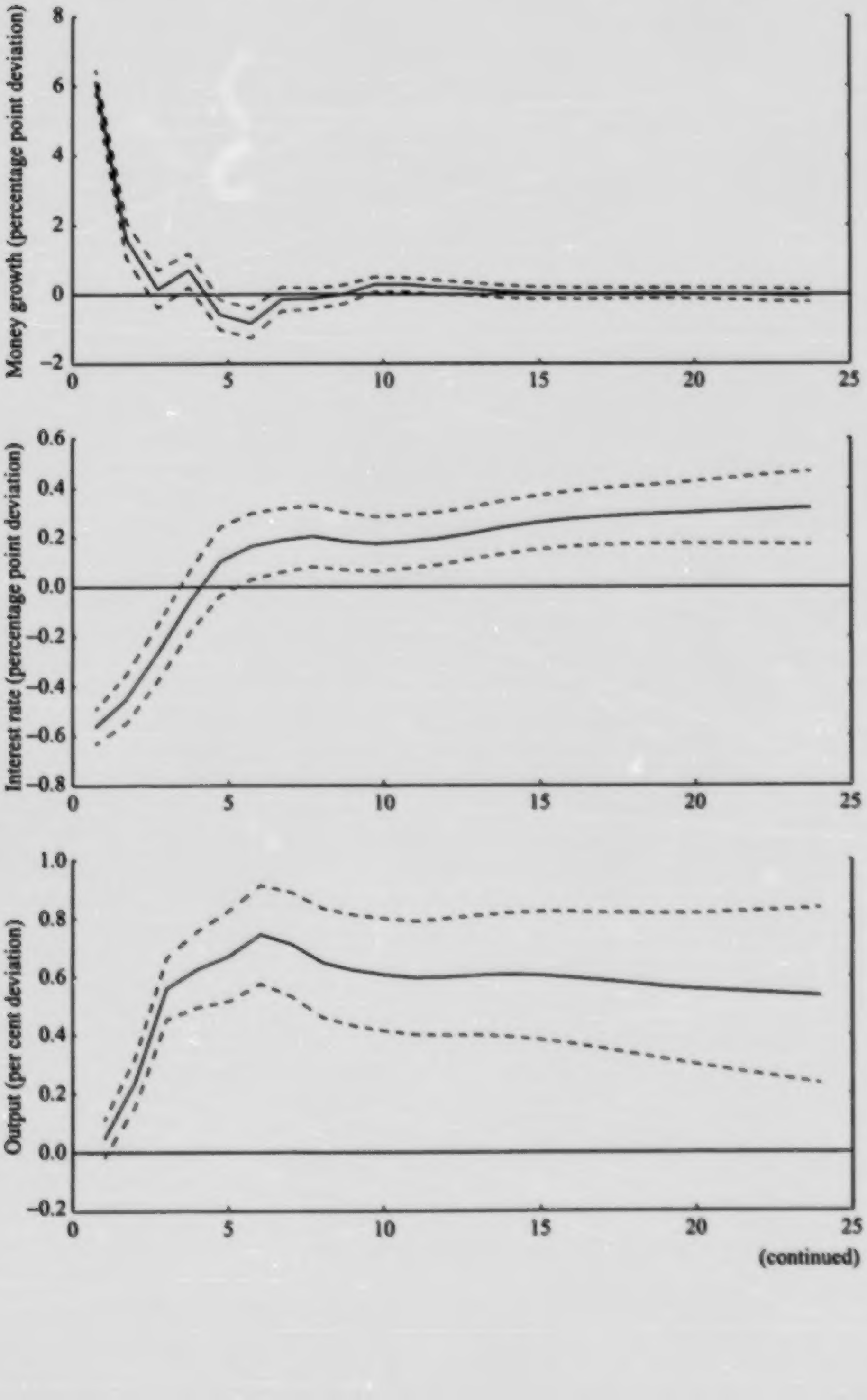
3.2 Some quantitative analysis

3.2.1 Liquid asset-holding decisions matter, even under full information

In the benchmark case, which is essentially a standard limited-participation model, we assume that banks can only take deposits from households and make loans to firms. As an alternative to this case, we examine how banks' lending behaviour changes when they are allowed to choose the optimal amount of liquid-asset holdings. In other words, we explore how introducing more realistic financial intermediaries changes the dynamics of some key macro variables following a monetary policy shock.

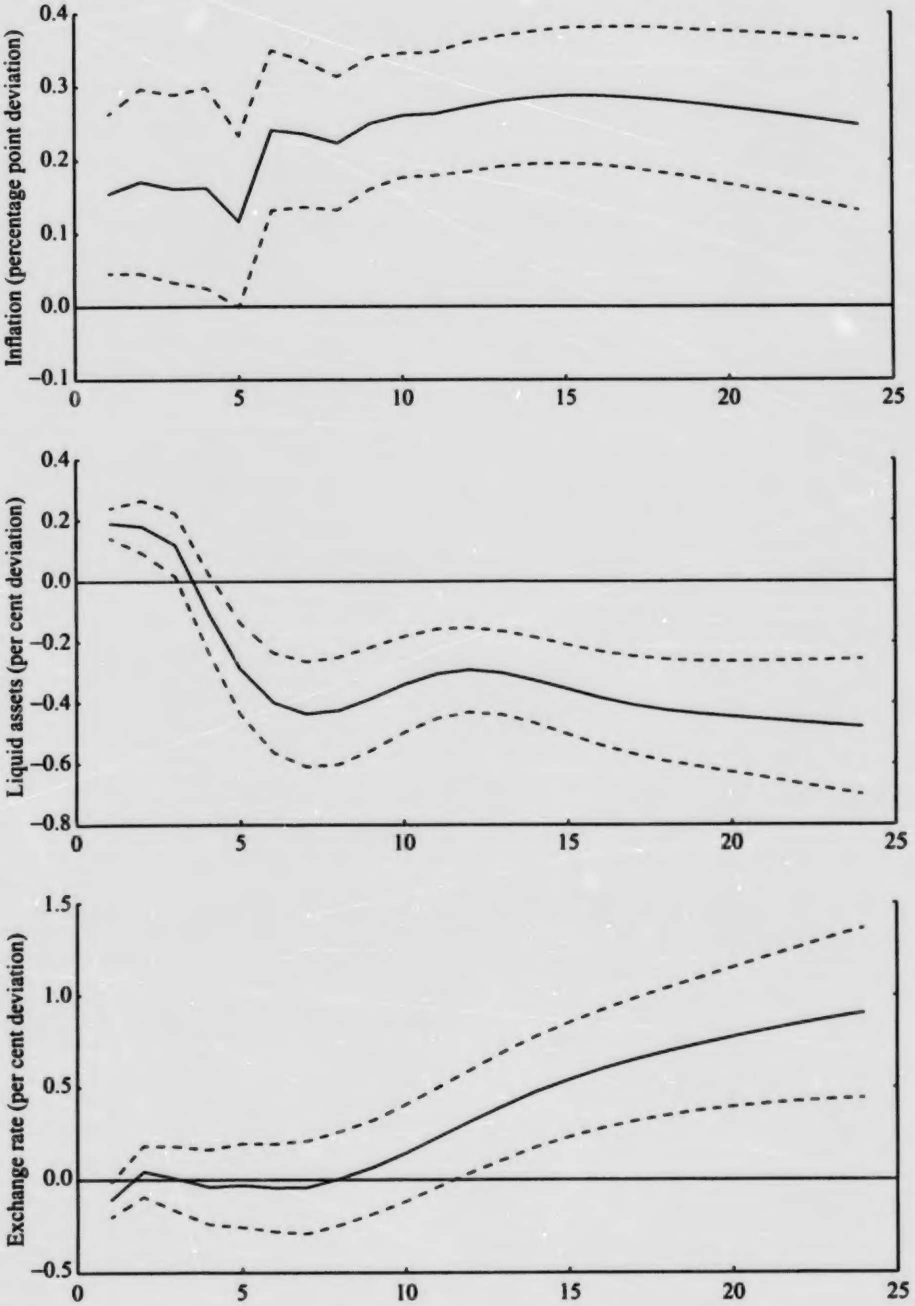
In Figure 2, we show the inflation, output, and interest rate responses following a policy shock to the money-growth rate when there is full

Figure 1
Impulse responses for empirical VAR on Canadian data, 1956 to 1998



(continued)

Figure 1 (continued)
Impulse responses for empirical VAR on Canadian data, 1956 to 1998



information about the nature of the policy shock. The responses tend to be large and short-lived when agents have full information, because only the initial shock is unexpected. Policy shocks are persistent, so the commercial banks correctly anticipate further monetary transfers in the second subperiod and, hence, run down their initial holdings of liquid assets when possible. This puts more money into the economy through increased lending to firms, thereby causing higher inflation and output responses. Because the lending market is flooded with funds, the interest rate liquidity effect is deeper when banks have the option to change liquid assets.

When there is a non-policy shock to the money-growth rate and agents have full information (see Figure 3), the banks can adjust their liquid-asset holdings to completely insulate the economy from the shock. The banks hold back all of the initial monetary injection, knowing that it will be removed by the central bank in the second subperiod. Liquid assets are built up, but lending to firms is unaffected. Inflation and output also remain unchanged at their steady-state values. If banks cannot adjust their liquid-asset position, then the new funds must be lent to firms, which causes the lending rate to fall and output to rise. The inflation rate spikes in the period of the shock, but immediately falls below steady state in the subsequent period as the initial injection is withdrawn from the economy.

3.3 Partial information

The impulse responses in Figure 4 show how beliefs matter to the propagation of monetary shocks when banks can optimize their mix of long-term lending and short-term investments.

In reality, private agents do not have perfect information regarding the central bank's policy changes or about the economic environment generally. For banks, correctly interpreting monetary policy actions is especially important for their decision-making process, because monetary transfers are made directly to them. In this model, agents' beliefs regarding policy can be derived with knowledge of three parameters: the ratio of the variance of x_t^p to the variance of x_t, $a = 0.1$, which controls the speed at which agents learn the true monetary shock; the autocorrelation coefficient of the policy component, $\rho = 0.5$; and the coefficient vector of the non-policy component, $b = -1$.

Figure 4 illustrates how banks misidentify a policy shock as a non-policy shock (the partial information case) and so they believe that, after the expansionary action in the first subperiod, the central bank will unwind the initial shock in the second subperiod. Thus, banks tend to invest more in liquid assets (borrow less from the central bank) and lend less to firms. This leads to a higher lending rate in the loan market, or a smaller liquidity effect,

Figure 2
Full information, policy shock

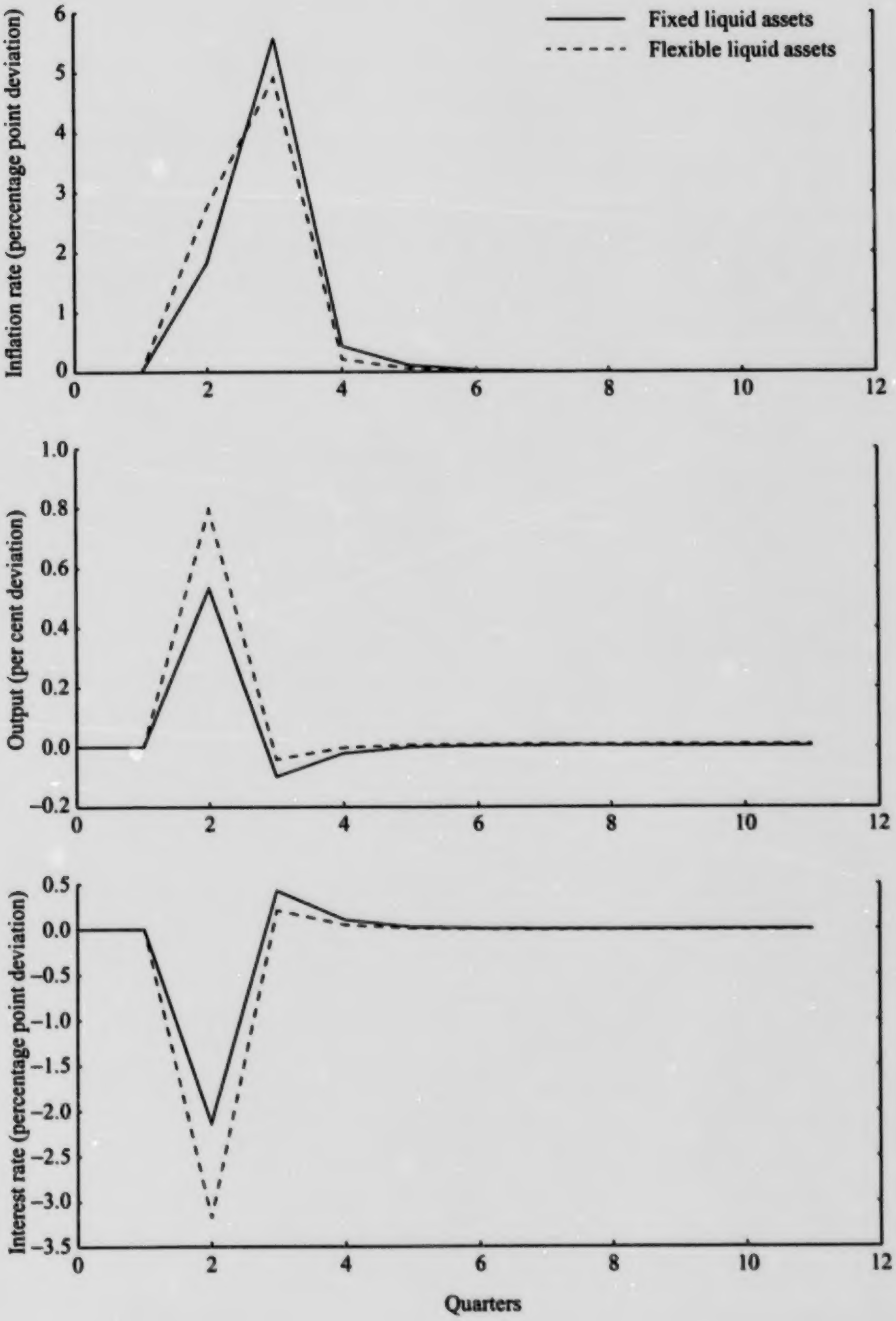


Figure 3
Full information, non-policy shock

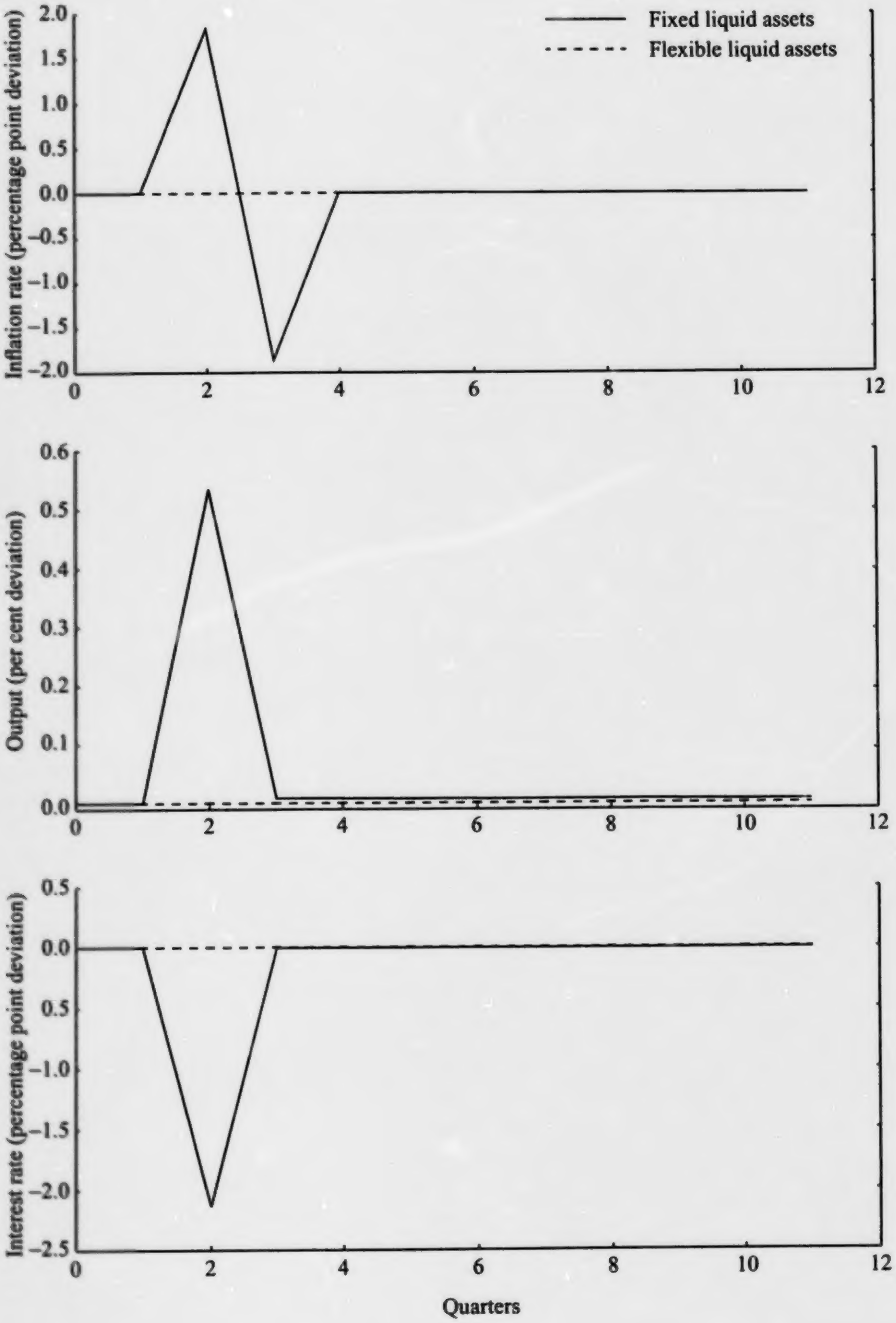
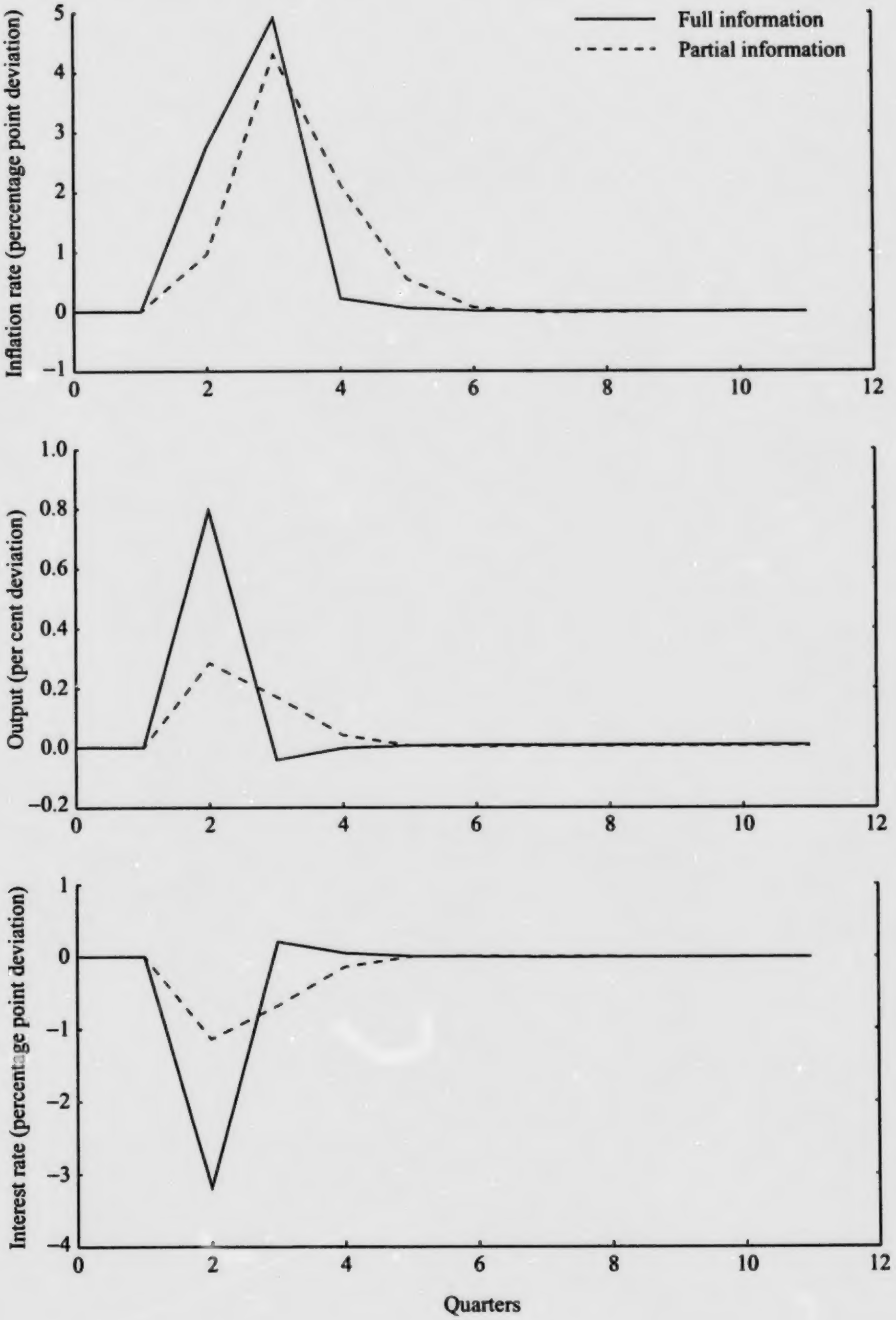


Figure 4
Flexible liquid-asset holdings, policy shock, partial versus full information



through a decline in the supply of loanable funds. The consequences are less investment, labour supply, and output. Households now receive less labour income and spend less on consumption. By investing more in liquid assets, banks hold money back from entering the goods market, creating less inflationary pressure.

The next policy shock experiment (Figure 5) compares the model with flexible liquid assets and partial information to the model with fixed liquid assets and partial information. Since banks expect the current shock to be reversed, they will tend to hold more funds as short-term investment in liquid assets, when possible, instead of lending to firms. Initially, there is less inflationary pressure in the economy as a significant portion of the liquidity injected into the economy by the central bank is "mistakenly" held back by the financial system and becomes non-productive for at least one period. The initial inflation response is reduced, but later adjustment is higher and somewhat more persistent. The effect on output and interest rates is more significant. That is, the output and interest rate responses are reduced notably, owing to the choices the banks made about their portfolio allocation.

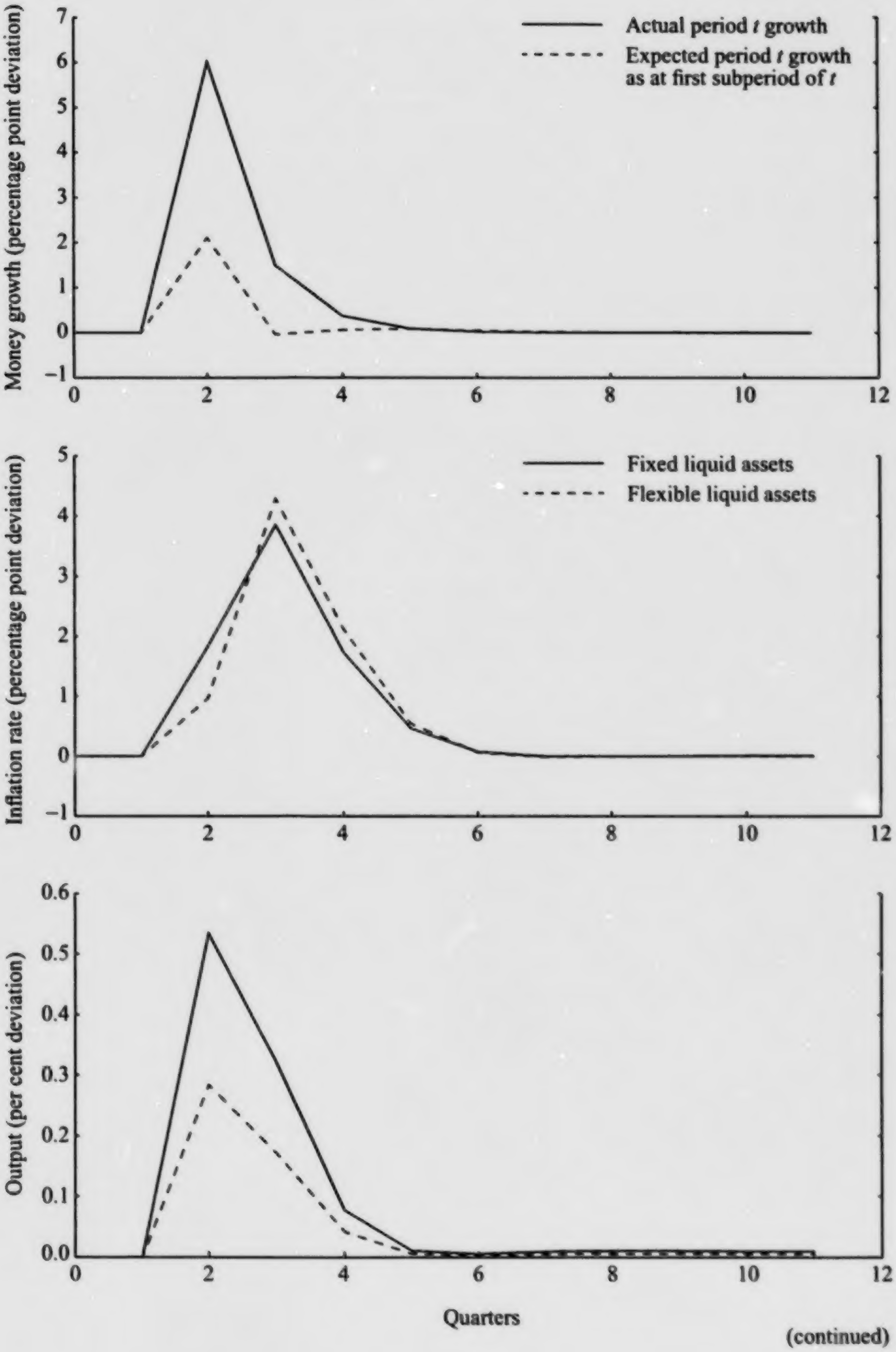
To highlight the points made in the previous impulse responses, in Figure 6 we present impulse responses for a more severe signal-extraction problem—when the weight on the policy component of the money-growth rate is only 0.01 instead of 0.1. The greater the information problem, the larger the impact of liquid-asset flexibility on the economy. The responses of inflation and output are smaller and more drawn out when the banks hold back more funds in the form of liquid assets.

Finally, in Figure 7 we show the impulse responses when there is a non-policy shock to the money-growth rate and partial information about the intent of the monetary policy shock. The responses are more volatile, because this shock is assumed to follow a negative MA(1). The ability of financial institutions to purchase liquid assets helps to insulate the economy from some of this volatility, although not as completely as in the full-information case shown in Figure 3.

4 Policy Implications and Conclusions

Financial intermediaries behave very differently depending on their information about the future of central bank policy actions. When there is an information friction, financial intermediaries' behaviour can reduce and prolong the effects of monetary policy actions. As well, when financial intermediaries increase their liquid-asset holdings, liquidity is diverted from the main lending channel, and less short-run inflationary pressure builds up

Figure 5
Partial information, policy shock



(continued)

Figure 5 (continued)
Partial information, policy shock

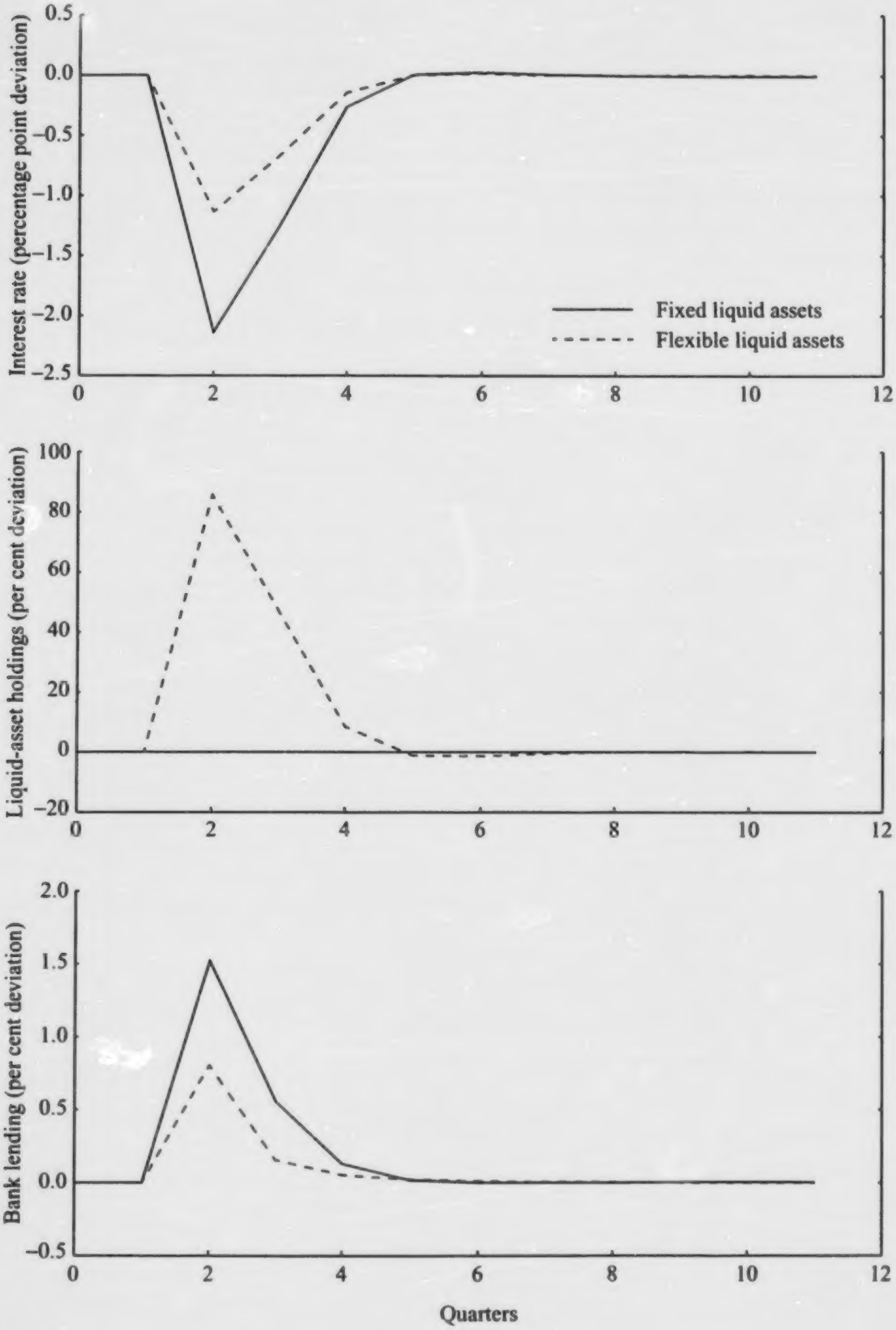


Figure 6
Flexible liquid assets, partial information, low weight on policy shock (a = 0.01)

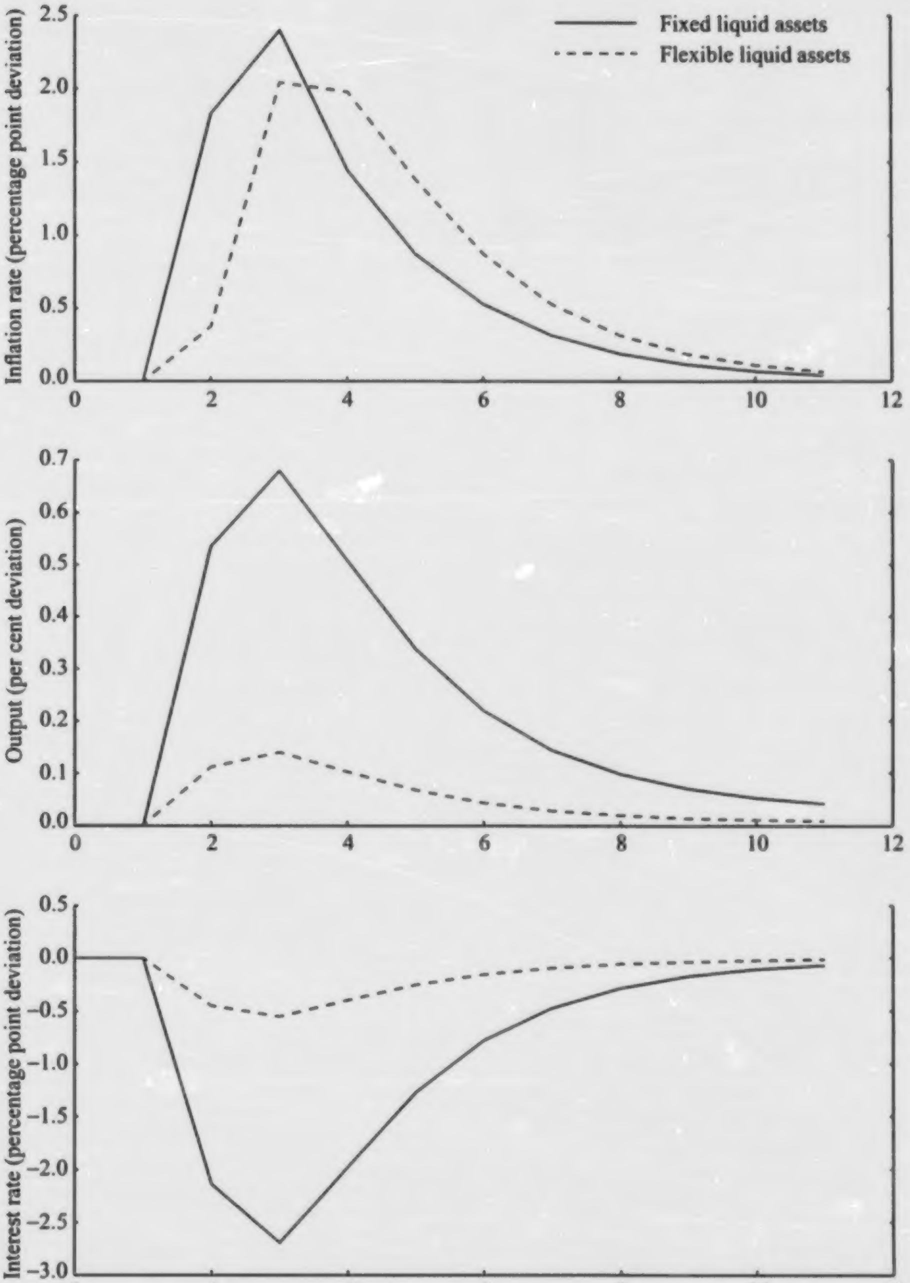
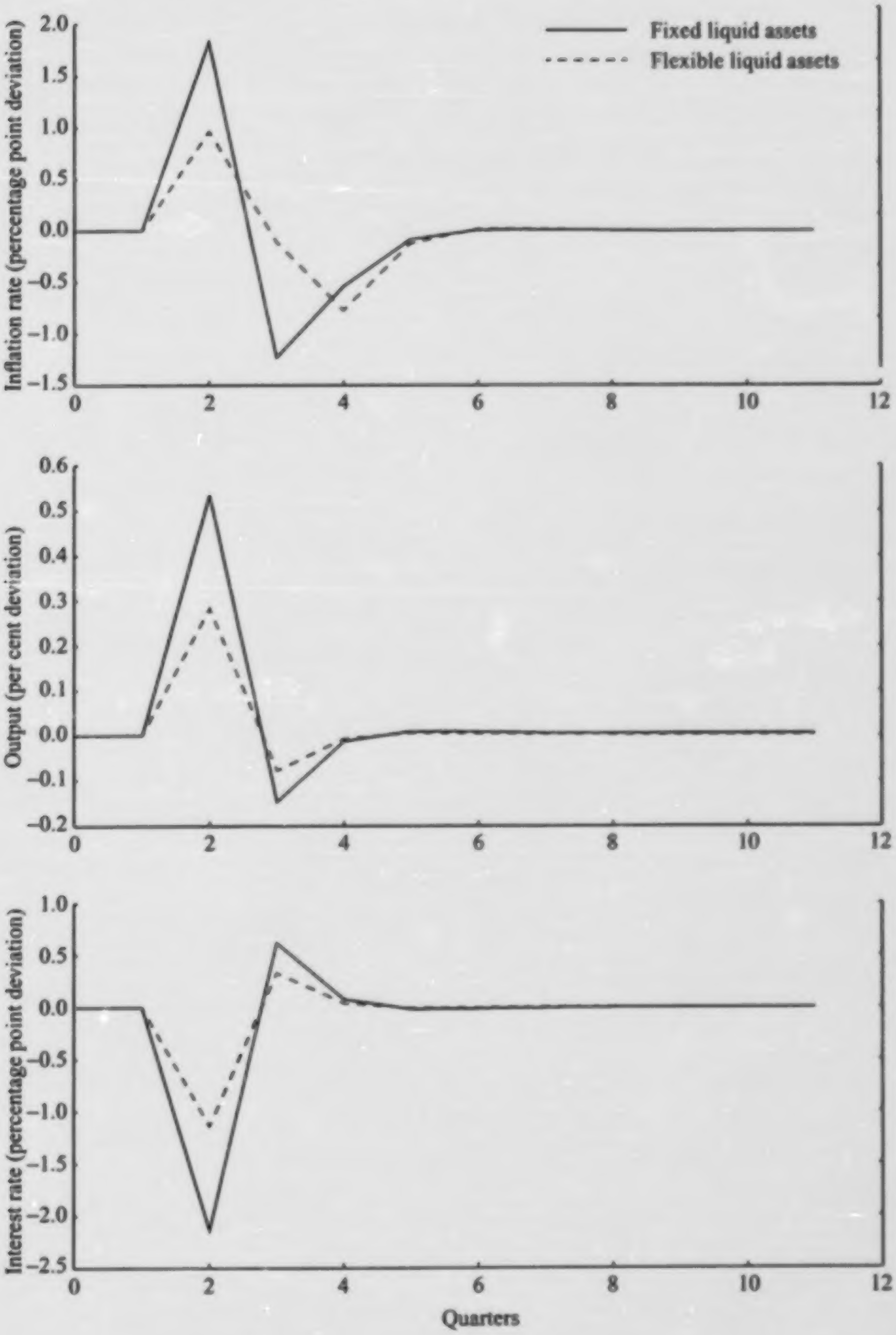


Figure 7
Partial information, non-policy shock



in the commodity market. The information friction is the main factor that determines the persistence of the liquidity effect in this type of models.

In sum, the effects of monetary policy actions in this class of models depend on the degree to which information frictions exist, and on banks' ability to adjust their lending behaviour in view of such frictions. More generally, these results suggest the importance of incorporating a meaningful financial sector in monetary general-equilibrium models; this would generate dynamic responses that correspond better to empirical results. Finally, we do not consider that our contribution completely explains the monetary transmission mechanism. Rather, we believe our model provides insights into episodes when there is much noise about the intent of monetary policy, and the role that financial intermediaries may play in these situations.

Appendix A1
Calibrating the Money-growth Process

The way we calibrate the money-growth process is very similar to that used in Andolfatto, Hendry, and Zhang (1999). As described in the main text, the money growth process includes two components—policy and non-policy—which agents do not observe individually.

$$x_t = x + x_t^p + x_t^{np} \tag{A1.1}$$

Specifically, the policy component follows an AR(1) process, and the non-policy component follows this MA(3) process:

$$x_t = \rho x_{t-1}^p + \varepsilon_t + \varepsilon_t^{np} + b_1 \varepsilon_{t-1}^{np} + b_2 \varepsilon_{t-2}^{np} + b_3 \varepsilon_{t-3}^{np}. \tag{A1.2}$$

Assume that the policy and non-policy components are orthogonal,

$$cov(x_t, x_{t-1}) = E[x_t^p x_{t-1}^p] + E[x_t^{np} x_{t-1}^{np}]. \tag{A1.3}$$

Divide both sides of the above equation by the variance of the x_t. We get

$$\begin{aligned} corr(x_t, x_{t-1}) = {} & corr(x_t^p, x_{t-1}^p) \cdot \frac{var(x_t^p)}{var(x_t)} \\ & + corr(x_t^{np}, x_{t-1}^{np}) \cdot \frac{var(x_t^{np})}{var(x_t)}. \end{aligned} \tag{A1.4}$$

Define

$$a \equiv \frac{var(x_t^p)}{var(x_t)} \tag{A1.5}$$

and

$$\eta \equiv corr(x_t^{np}, x_{t-1}^{np}). \tag{A1.6}$$

Given that the correlation coefficient of x_t is 0.53 in Canada,

$$\eta = \frac{0.53 - a \cdot \rho}{1 - a}. \tag{A1.7}$$

From

$$var(x_t^p) = \frac{\sigma_\varepsilon^2}{1 - \rho^2} \tag{A1.8}$$

and

$$var(x_t^p) = a \cdot var(x_t) = (0.013)^2 \cdot a, \tag{A1.9}$$

the policy shock is determined by

$$\sigma_\varepsilon^2 = (0.013)^2 \cdot a \cdot (1-\rho^2). \tag{A1.10}$$

The non-policy component follows an MA(3), so:

$$\begin{aligned} var(x_t^{np}) &= \sigma^2 + b_1^2 \cdot \sigma^2 + b_2^2 \cdot \sigma^2 + b_3^2 \cdot \sigma^2 \\ &= (1-a) \cdot var(x_t). \end{aligned} \tag{A1.11}$$

This allows us to pin down the value of the variants of non-policy shocks to

$$\sigma^2 = \frac{(0.013)^2 \cdot (1-a)}{1 + b_1^2 + b_2^2 + b_3^2}. \tag{A1.12}$$

Appendix A2
Solution Method

The model is solved using two different methods, each providing a check on the other. The first method preserves the non-linearities present in the equations of the model, whereas the second forms a linear approximation to those equations. The differences between the impulse responses obtained using these two methods are negligible. Below, we briefly describe both solution methods. Details can be obtained from the authors.

Non-linear method

The first method is the simplest in design. Let the system be defined by n equations representing the first-order conditions and the equilibrium relations of the system. These n equations must each be satisfied for every period $t = 1, \ldots, T$. Imagine we are in a perfect-foresight framework, where a sequence of shocks from $t = 1, \ldots, T$ is perfectly anticipated. The starting values of the state variables give the system its initial conditions. Requiring the system to be back at steady state after T periods delivers terminal conditions. We are thus left with a system of nT equations in nT unknowns (the values of the n variables in each of the T periods). Provided n and T are not too big, an equation solver can easily find the solution to such a perfect-foresight problem.

The model presented in this paper is stochastic. However, we can use a combination of several perfect-foresight problems to arrive at a solution. To do so, define, in the first round, the perfect-foresight sequence of shocks as follows: the actual shock for the first period, and the expected shocks generated by the updated beliefs of agents for the $T-1$ remaining periods. Solve the T-periods system with these shocks. This delivers a solution that contains the actual values of the endogenous variables for the first period and these variables' expected paths from period 2 on. Keep the first period's solution. The second round picks up the end-of-period-1 values as the initial conditions, defines a new sequence of shocks (with the actual period-2 shocks and the expected shocks for period 3 on), and solves the $T-1$ system. The solution gives the actual value of the variables at time 2 and the variables' expected paths from period 3 on. Continuing this process until T rounds have been finished completely solves the stochastic problem.

Linear method

The second solution method forms a linear approximation to the system. The algorithm used is an extension to those presented in King and Watson

(1995). The extension is necessary to account for the agents' imperfect information and the process by which their beliefs evolve. In King and Watson, the solution takes the following form:

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \Pi \cdot \begin{bmatrix} k_t \\ \delta_{t-1} \end{bmatrix} + \eta_1 \cdot \varepsilon_t \tag{A2.1}$$

and

$$\begin{bmatrix} k_{t+1} \\ \delta_{t+1} \end{bmatrix} = M \cdot \begin{bmatrix} k_t \\ \delta_t \end{bmatrix} + \eta_2 \cdot \varepsilon_t, \tag{A2.2}$$

where the vector y_t represents the endogenous variables of the system and k_t the predetermined state variables. Exogenous shocks are arranged according to a state-space representation. As in Hamilton (1994), the observed variables from that state-space system are x_t, the state variables are δ_t, and the innovations to these state variables are ε_t.

King and Watson's algorithm assumes that agents can perfectly observe the state vector δ_t. By contrast, in the model presented in this paper, agents do not observe perfectly δ_t, but instead form expectations of these variables, according to both the information received previously and their initial beliefs. The Kalman filtering described in the main text governs the way these beliefs are updated. In every period, the value of all endogenous variables now depends both on the current beliefs and the current shocks, and the weight is placed on the beliefs depending on the severity of the information problem. Denoting $\hat{\delta}_t = E[\delta_t | \Omega_{1t}]$ with Ω_{1t} representing the information set available to agents at the very beginning of period t, the system now evolves according to this process:

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \Pi^* \cdot \begin{bmatrix} k_t \\ \hat{\delta}_t \\ \delta_{t-1} \end{bmatrix} + \eta^*_1 \cdot \varepsilon_t \tag{A2.3}$$

and

$$\begin{bmatrix} k_{t+1} \\ \hat{\delta}_{t+1} \\ \delta_t \end{bmatrix} = M^* \cdot \begin{bmatrix} k_t \\ \hat{\delta}_t \\ \delta_{t-1} \end{bmatrix} + \eta^*_2 \cdot \varepsilon_t. \tag{A2.4}$$

Details on the exact form of these matrices and the way to compute them are available on request from the authors.

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Discussion

Paul Gomme

Amano, Hendry, and Zhang contribute to a general research agenda that aims to understand how the monetary transmission mechanism works within monetary dynamic general-equilibrium models to gain greater confidence in policy advice based on this class of models. What evidence do they wish to explain? Using their estimated VAR, they show that following a positive innovation to money growth, there is:

- a buildup of liquid assets at chartered banks
- a decline in the nominal interest rate lasting three quarters
- a hump-shaped response in output peaking five quarters after the shock
- a peak response in inflation at 15 quarters

While Amano, Hendry, and Zhang estimate their VAR using Canadian data, U.S. data would reveal a similar pattern (although some measure of reserves typically takes the place of liquid assets in the U.S. VARs).

The authors used the limited-participation model of Lucas (1990) and Fuerst (1992). Most work in this area has focused on the interest rate and output responses to a monetary shock. Models of this class typically have difficulty generating much persistence in the interest rate and output responses. The key innovation in Amano, Hendry, and Zhang's work is to introduce liquid assets into an otherwise standard limited-participation model. The authors model the demand for liquid assets as arising from different stochastic processes governing the policy and non-policy components of money growth, and the possible confusion by banks concerning the source of the money shock. By delving further into how exactly changes on the central bank's balance sheet are transmitted to the real economy via the banking system, the authors clearly hope to address some of the deficiencies of the limited-participation model. This is, indeed, a tall order!

Banks wish to end each period with zero liquid assets. Should a bank end a period with negative liquid assets, it must borrow from the central bank at a penalty rate that is above the rate that the bank pays on its deposits. On the other hand, should a bank have a positive liquid-asset position at the end of a period, the return offered by the central bank is below that earned on its loans to firms.

However, within a period, a bank may wish to have a liquid-asset position different from zero. To start, consider the full-information case. A positive innovation to money growth in the first subperiod will lead to a positive innovation to money growth in the second subperiod owing to the positive autocorrelation in the policy component. Since banks want to end the period (that is, the second subperiod) with zero liquid assets, they will commit (in the first subperiod) to a level of loans that exhausts deposits plus the innovations to money growth in the two subperiods. That is, banks will have a *negative* liquid-asset position at the end of the first subperiod.

Now, suppose that the source of the money growth innovation in the first subperiod is the non-policy component. Then banks know that this innovation will be completely reversed in the second subperiod, since the non-policy component follows a negative first order moving average process (with a coefficient on past innovations of −1). In this case, banks will run up their liquid asset position in the first subperiod and will not change the level of loans in response to this shock. The second subperiod money shock then "drains" the banks' liquid assets from the system.

Next, consider the imperfect information case. Banks must now infer the source of a money shock in the first subperiod based on observed money growth (and knowledge of the underlying stochastic processes governing the behaviour of the policy and nonpolicy components). In general, banks will place some weight on both the policy and non-policy components. Since the authors assume that the predominant source of variability in money growth is the non-policy component, one would anticipate that banks would place a much higher weight on the likelihood that the source of a money shock is the non-policy component. In the face of a money growth innovation in the first subperiod banks will loan out a small part (since they place some weight on the policy component) and will run up their liquid-asset position (since they place a large weight on the non-policy component). Should the true source of the money shock be the policy component, banks will end the period with a positive liquid-asset position (they did not lend out "enough"). However, if the source of the shock is the non-policy component, banks will end with a negative liquid asset position (they lent out a small part of the first subperiod injection).

The first and second subperiod notation is somewhat clumsy. Consider an alternative specification of money growth. As in Amano, Hendry, and Zhang, let money growth be divided into a policy and non-policy component:

$$x_t = x_t^p + x_t^{np} + \bar{x}, \tag{1}$$

where $\bar{x}$ is the long run average money-growth rate. Further suppose that the policy component is positively autocorrelated:

$$x_t^p = \rho x_t^p + \varepsilon_{1t}, \quad 0 < \rho < 1. \tag{2}$$

Next, let the non-policy component be "noise":

$$x_t^{np} = \varepsilon_{2t}. \tag{3}$$

Finally, suppose that at the start of the period, a signal of money growth, π_t, is revealed:

$$\pi_t = x_t + \varepsilon_{3t}. \tag{4}$$

Assume that $\varepsilon_t \equiv [\varepsilon_{1t} \quad \varepsilon_{2t} \quad \varepsilon_{3t}]' \sim N(0, \Sigma)$ where Σ is diagonal (which implies that the shocks are independent). Banks must commit to the level of loans based on the signal π_t.

This information structure is identical to that of Kydland and Prescott (1982). Consequently, their formulas describing the signal extraction process can be applied directly.

An advantage of the proposed information structure is that there is *no need* to take a stance on the (relative) lengths of the two subperiods in Amano, Hendry, and Zhang. This issue is problematic in their paper since, at one point, they assume that the first subperiod is "short enough so that no return is earned." Yet in their calibration section, the authors assume that the two subperiods are of equal length. In the formulation above, all that is needed is an assumption that banks commit to loans based on the signal π_t (whenever that signal may be received).

A further advantage of the proposed information structure is that one can separate out the noisy signal (π_t) from the confusion over the policy and non-policy components of money growth by playing around with the variances of the ε shocks.

Calibration: Money Growth

For the most part, the authors' calibration is similar to that in the existing dynamic general-equilibrium literature. An exception is the set of parameters governing the money-growth process, summarized in Table 1.

The first two parameters are chosen to match Canadian M1 growth (its average growth and volatility). Appendix A1 suggests that Amano, Hendry, and Zhang also use the first-order autocorrelation of Canadian M1 growth to identify one of the parameters in Table 1. However, unlike Andolfatto and Gomme (1999), it seems unlikely that the authors will be able to use univariate time series techniques to pin down all of their free parameters. The key parameter is how much the policy component contributes to overall variability in money growth. While the authors perform some sensitivity analysis over this parameter, it is difficult to gauge the reasonableness of the values they consider.

Impulse Responses

Given that the innovation in Amano, Hendry, and Zhang is the introduction of liquid assets to a limited-participation model, it is disappointing that they present only one figure showing the model's prediction for this series.

The paper is also largely silent on the size of the shocks used in the impulse responses. In the calibration, the policy component contributes only 10 per cent to the overall volatility of money growth. Yet, the responses to the policy shock are of the same order of magnitude as those to non-policy shock. One might have expected the policy shock to generate responses an order of magnitude smaller than the non-policy shock. During the conference, it became clear that the authors used shocks of the same size for the policy and non-policy experiments. An interpretation that could potentially reconcile this apparent conflict is that the policy shocks simply occur less frequently. However, such an interpretation is *inconsistent* with the description of the money-growth process in the rest of the paper. There is a difference between small, frequent shocks on the one hand and large, infrequent shocks on the other.

Table 1
Period length: Six weeks

Average money growth	0.55%
Money variability, SD(x)	0.0013
Relative variability, SD(x^p)/SD(x)	10%
Autoregression (AR) coefficient on x^p	0.5
Moving average (MA) order for x^{np}	1

Summing Up

The authors set a difficult task for themselves: Construct a monetary dynamic general-equilibrium model that can explain the behaviour of chartered bank liquid assets, the nominal interest rate, output, and inflation. Accounting for the behaviour of the interest rate and output—particularly the persistence following a monetary disturbance—has generally proved difficult; see, for example, Christiano (1991). Adding liquid assets to the mix raises the bar considerably.

As a first pass at this problem, the authors do a good job. There is, of course, room for improvement. For example, their model would seem to predict that chartered banks should hold, on average, zero liquid assets. Yet, in footnote 1 they report that "liquid assets comprise, on average, a significant 12 per cent of Canadian dollar assets." (See page 283.) Presumably, banks hold liquid assets as more than a simple buffer against the policy and non-policy shocks considered by Amano, Hendry, and Zhang. It would also be desirable to bring more evidence to bear on the authors' choice of the parameters governing the policy and non-policy components of money growth. No doubt, future work, including Andolfatto et al. (1999), will address these and other issues.

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Discussion

Sylvain Leduc

Amano, Hendry, and Zhang study an important and interesting question: How does financial intermediation affect the monetary transmission mechanism? They extend the standard liquidity model by:

- modelling more specifically the investment decisions by banks, allowing them to allocate funds between longer-term loans and shorter-term liquid assets; and
- assuming that private banks have imperfect information.

The idea behind their study comes, in part, from empirical evidence from VARs that shows that the ratio of banks' liquid assets to total assets rises following a monetary expansion. (Bernanke and Blinder [1992] found similar results for the United States.) The paper's underlying theme is that the nature of monetary shocks is not always transparent: Banks may have difficulty distinguishing whether or not the movements in monetary aggregates will be long-lasting. Therefore, if they consider the possibility that movements in monetary aggregates will be reversed soon after they have been observed, they will hold more liquid assets to use as a buffer against this uncertainty.

The authors find that these two factors, in an otherwise standard liquidity model, can significantly alter the economy's response to changes in monetary policy. In particular, they dampen and prolong the effects of monetary shocks. Of course, the quantitative importance of their results will depend, to a large extent, on how quickly private banks learn about the cause of movements in monetary aggregates. However, Amano, Hendry, and Zhang do not calibrate the parameter dictating the speed of learning and arbitrarily set it so that banks learn slowly. I will suggest a way of calibrating the belief process, and I will argue that, based on this calibration, it appears likely that the effects of financial intermediation on the monetary transmission mechanism, in their model, will be quantitatively small. As a result, it seems unlikely that their framework will provide a satisfactory explanation for the empirical evidence from their VARs.

However, first let me briefly review part of the structure behind the paper. The authors assume that the stock of money in the economy, X, can result from two different components: a policy component, X^p, and a non-policy component, X^{np}. X^p is assumed to follow an AR(1) process with a persistence parameter equal to 0.5. On the other hand, X^{np} is assumed to follow a negative moving average process, so any change in that component will be reversed in the subsequent few periods. Again, it is assumed that only the central bank knows why the stock of money changed in the economy. Banks, however, must form beliefs about the part of a given change in X that comes from a change in X^p or X^{np}. Here, banks will extract information about X^p and X^{np}, based on a Kalman filter.

What will be critical for the quantitative results (although it does not change the qualitative aspect of the paper) is the calibration of the learning process. It turns out that the ratio of the policy component's variance to the variance of the money stock will dictate the learning speed. The authors set this ratio to 0.1, implying that agents learn slowly about policy shocks. They are very clear about this parameterization, and are not trying to argue that it is particularly realistic. However, I wondered about how often we actually see reversals in monetary aggregates and how important the policy component is relative to the monetary aggregate. One way of calibrating the learning speed would be by first assuming that the central bank uses an interest rate rule. Although this is not necessary, it will make my discussion easier. A lot of research has been done trying to decompose the part of the effective federal funds rate that is due to policy changes. Here, the approach adopted by Sellon (1994) could be helpful, and I will use his research, since he reconstructed a policy component for the federal funds rate from 1974 onward.[1]

Sellon develops a measure of policy changes for each operating regime in the 1974–93 period and then links them in a single, comprehensive measure of policy actions. From the mid-1970s to October 1979, the Fed targeted the federal funds rate and used open market operations to keep the funds rate within the targeted range. But, since policy changes were not publicly announced during this period, Sellon relies on weekly reports on open market operations by the trading desk of the New

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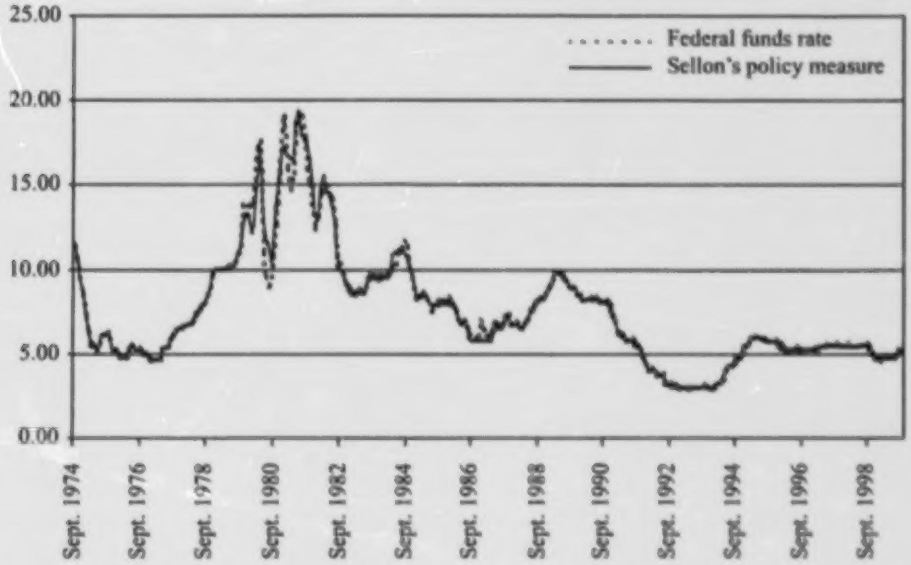
[1] Note that the authors calibrated their model to the Canadian economy. Using the policy measure for the United States can, nevertheless, provide some indications on the likely speed of learning in Canada.

Figure 1
Federal funds rate and Sellon's policy measure



York Fed to construct a measure of policy changes. Starting in October 1979, the Fed shifted to a nonborrowed reserves target. Again, Sellon uses information from the weekly reports on open market operations by the trading desk for information on changes in the nonborrowed reserve path. According to him, these reports separate policy from non-policy changes and provide the size of each change. From October 1982 to 1989, the Fed started watching borrowed reserves. Sellon uses borrowing targets to construct a measure of policy actions in that period. Finally, beginning in December 1989, the series is constructed using the federal funds rate series.[2] The final policy measure is constructed by translating policy changes in the nonborrowed reserve path and borrowing targets into an equivalent change in a federal funds rate target.

Figure 1 shows both the effective federal funds rate and the measure of policy changes. Obviously, both series are nearly identical. Therefore, if we were to conduct the authors' exercise in terms of the federal funds rate, we would say that banks observe the effective rate, but not policy changes. However, since the variances of both series are close to 1, this would suggest that banks would learn very quickly: The parameter *a* would be close to 1, rather than 0.1. Consequently, using Sellon's policy measure, the authors could calibrate their learning process more realistically and present a more convincing quantitative analysis of the effect of financial intermediation on the monetary transmission mechanism.

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[2] In 1994, the Fed started announcing policy changes at the end of FOMC meetings and, in 1997, it began to publicly announce its explicit federal funds rate target.

Therefore, it is likely that U.S. banks learned fairly quickly about monetary policy changes from 1974 to 1999. As a result, the dampening and the prolonging impact of the imperfect information of banks and their investment behaviour are likely to be quantitatively small. With faster learning, financial intermediaries in the model will not accumulate a lot of liquid assets in response to an expansionary monetary shock. Therefore, I have some doubts that the channel emphasized by the authors can account for the empirical evidence from their VARs that shows an increase in banks' holdings of liquid assets following a positive monetary shock. Therefore, in an otherwise standard liquidity model, the effects on the monetary transmission mechanism of assuming that banks have imperfect information about the persistence in the movements in monetary aggregates is likely to be quantitatively small. However, this being said, I still view the qualitative channel investigated by Amano, Hendry, and Zhang as significant, especially when central banks lack clarity on their designated objectives.

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General Discussion

In response to the discussants' comments about the slow calibration of the money-growth process, Scott Hendry noted that they tried to estimate policy responses for Canada, but that the standard errors were quite large. He pointed out that the model misses many types of uncertainty about monetary policy, which could make the slow bank-learning process in the model seem less extreme. He argued that the policy response in the model should be interpreted as episodic, since policy shocks can be unclear in certain circumstances. Zhang added that, in fact, financial markets misinterpreted three out of four of the Fed's last policy moves. The transparency of monetary policy is still an important issue to policy-makers and financial intermediaries.

A few participants commented on several shortcomings of the model's institutional structure. David Laidler, of the University of Western Ontario, noted that money is used as a policy instrument in the model, but in reality it is a liability of financial institutions. Thomas Rymes, of Carleton University, pointed out that under the current procedure of setting operating bands for the overnight rate, changes in the bands do not initiate an adjustment of liquid assets, because borrowing or lending by the banks is not affected. Chuck Freedman, of the Bank of Canada, also commented that the institutional structure in the paper is more relevant to that of the 1950s. He said that monetary policy actions taken now are not liquidity injections, but changes in the overnight rate that the banking sector then responds to by adjusting liquid assets.

Hendry agreed that money creation was needed in the model and that the institutional structure in the model was not in line with the current

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* Prepared by Ron Lange.

framework. He noted that in the current environment, the central bank operates in the short-term market, while the public operates in the longer end of the market. He emphasized, however, that the purpose of the current specification is only to capture the importance of portfolio choice by financial institutions.

Lawrence Christiano, of Northwestern University and the Federal Reserve Bank of Chicago, noted that there is a signal-extraction problem with endogenous money, because the monetary policy process is exogenous. He felt that the policy responses from the model should be compared with some measure of exogenous money and not compared with the VAR impulse responses, since these responses also include the reaction of money to other factors. Zhang agreed that it was not appropriate to directly compare the VAR and model responses. The empirical VAR results serve as only a qualitative guideline in the paper.

Credit Crunch, Bank Lending, and Monetary Policy: A Model of Financial Intermediation with Heterogeneous Projects

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Mingwei Yuan and Christian Zimmermann

Introduction and Motivation

A credit crunch is generally defined as a decline in the supply of credit because, although banks are less willing to lend, lending rates do not rise. According to Green and Oh (1991), a credit crunch is an inefficient situation in which credit-worthy borrowers cannot obtain credit at all, or cannot get it at reasonable terms, and lenders show excessive caution, which may or may not be traceable to regulatory distortion, leaving would-be borrowers unable to fund their investment projects. A credit crunch can have several causes, such as regulatory pressures and over-reaction to deteriorating bank asset values and profitability. If regulatory pressure is the obstacle to credit growth, it should be removed, and credit growth can be restored. But if the crunch is caused by inefficient conservative lending by banks, it is an open question whether easing monetary policy can help. This paper attempts to develop a quantitative model to address the issue.

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A number of papers suggest that a credit crunch existed in several countries in the early 1990s. From survey data in Germany, Harholf and Korting (1998) find that firms in financial distress face comparatively high line-of-credit interest rates and reduced credit availability. Using Finnish data from the 1990s, Vihriala (1996) finds that tightening capital regulations, substantially depleting bank capital, and changing risk attitudes may explain banks' conservative lending. Using a disequilibrium econometric model, Pazarbasioglu (1996) also suggests that banks become less willing to supply credit during periods of deteriorating asset quality and reduced profits caused by declining regulatory protection from competition and a need to increase capital-adequacy levels.

In 1990–91, U.S. banks curtailed their lending. Sharpe (1995) claims this occurred because of losses of bank capital, stringent bank regulatory standards, and heightened market scrutiny of bank capital. The Bank for International Settlements risk-based capital standards were phased in beginning in late 1990 and took full effect in 1992. The reduced credit occurred at a time when banks had difficulty meeting their minimum-capital adequacy requirements. According to Bernanke and Lown (1991), the regulatory pressures on bank capital positions would shift the credit supply curve to the left, given constant real interest rates and the same quality of borrowers. Using New England bank data, Peek and Rosengren (1995) find empirical evidence supporting the hypothesis that banks have experienced a capital crunch caused by large capital losses and binding capital regulations.

An interesting, recent paper by Wagster (1999) examines the 1989–92 credit crunch in the United States, Canada, and the United Kingdom. Four supply-side credit crunch hypotheses are proposed: (i) voluntary risk reduction by bank managers, (ii) tighter scrutiny by bank regulators, (iii) risk-based capital requirements following the 1988 Basle Accord, and (iv) the unweighted capital ratio imposed by U.S. bank regulators. The results show that none of the four hypotheses can be eliminated as explanations for the U.S. credit crunch. For Canada, the results conform to the risk-based capital requirement and tighter regulatory scrutiny hypotheses. For the United Kingdom, tighter regulatory scrutiny is the explanation for the crunch.

The recent credit crunch in Japan has drawn a lot of attention from researchers and policy-makers. The banks' capital positions have been eroded by deteriorating loan quality and losses of banks' security holdings. Furthermore, banks were reluctant to issue new equities because of unfavourable market conditions. To meet the minimum-capital adequacy requirement, banks had to reduce their loans. This pushed marginal borrowers into bankruptcy, putting more pressure on the banks' capital position. Woo's (1999) empirical results based on the data suggest a credit crunch in 1997, but not during most of the rest of the 1990s. The Bank of Japan and the Japanese government have taken measures to deal with the crunch, such as lowering nominal short-term interest rates to near zero, injecting capital into several commercial banks, and relaxing capital adequacy requirements by way of accounting changes.

What can monetary policy do to help during a credit crunch when reduced bank lending leads to a shrinking economy? The question is related to the transmission mechanism of monetary policy. One transmission channel of monetary policy is credit. Expansions and contractions of credit affect both aggregate demand and aggregate supply, thus influencing aggregate activities and prices.

The credit channel of monetary policy has been drawing much attention from researchers recently. In the credit-channel stories, financial market imperfection is an important factor of the transmission mechanism—a financial accelerator effect. Because of frictions in credit markets, different financing sources are imperfectly substitutable, especially for bank credit. Given asymmetric information in financial markets, the impact of monetary policy will be amplified and distributed among borrowers through two channels: the lending channel and the balance sheet channel. The lending channel (Bernanke and Blinder 1988) works through the supply side of credit. A tight policy reduces the supply of bank loans, which in turn reduces spending by borrowers that depend on banks. The balance sheet channel (Bernanke and Gertler 1995) works through the demand side of credit. A tight policy weakens borrowers' balance sheets, which reduces their ability to borrow. A shrinking loan supply leads to a rising lending rate, which would discourage bank-dependent borrowers' activity. Instead of raising the interest rate on loans, banks can also ration credit. Banks ration credit rather than raise interest rates because of asymmetric information between borrowers and lenders. The problems of moral hazard and adverse selection can lead to credit rationing (Keeton 1979, Stiglitz and Weiss 1981). In addition, Williamson (1986) develops a model in which credit rationing arises from monitoring cost.

Several papers provide empirical evidence on credit channels of monetary policy. Banks lend more to large firms and less to small ones after a tightening policy (Gertler and Gilchrist 1994, Li 1997). Lang and Nakamura (1995) also find that banks make proportionally more safe loans during financial distress. Morgan (1998) uses a contractual difference across commercial bank loans to test for credit effects. Most commercial banks issue loans under a commitment contract, for example, revolving lines of credit. This kind of contract sets the terms of future lending in advance, which would prevent a sudden contraction in the supply of loans under commitment. However, banks have a choice to reduce loans not under commitment. Thus, by comparing the supplies of these two kinds of loans, one can examine credit effects of monetary policy. Morgan uses two monetary policy indicators, Romer and Romer dates, and the federal fund rate. The results show that a tight monetary policy slows the growth of loans not under commitment, while the growth of loans under commitment is unaffected or accelerates. By further examining the responses of bank loan officers and small firms to survey questions about the availability of credit, Morgan finds that the divergence reflects a shrinking loan supply due to credit effects.

Frictions in financial markets are thought to be an important channel for propagating monetary policy shocks. Studies of the credit channel by Fuerst (1995) and Fisher (1996) suggest that it is quantitatively unimportant. However, Bernanke, Gertler, and Gilchrist (1998) develop a model by considering external finance premiums and the net worth of borrowers. The model shows that credit market frictions may significantly amplify both real and nominal shocks to the economy. Cooley and Quadrini (1998) consider a model in which firms' financial decisions differ systematically with the amount of equity they issue. The capital structure of firms changes endogenously over time as a result of their financial decisions. The model provides insight on the importance of firm heterogeneity as a channel of transmission for monetary policy. Nevertheless, Cooley and Quadrini find the aggregate real effects of monetary shocks to be very small, similar to the empirical result of Sims (1992) and Leeper, Sims, and Zha (1996).

Several papers discuss credit-crunch models. Peek and Rosengren (1995) provide a simple one-period model of banks. Banks face binding capital constraints as a result of large loan losses and low or no earnings. This causes banks to behave differently than they would if the requirements were not binding. Chan-Lau and Chen (1998) consider a model of private-debt financing under inefficient financial intermediation, where inefficiency is characterized by costly loan monitoring. They use the model to study large capital outflow and credit crunches in Asian countries in recent years.

In this paper, we develop a dynamic heterogeneous-agent model to study credit crunches and the effectiveness of monetary policy. In this model, a credit crunch is caused by banks' conservative lending behaviour during periods of reduced profitability and financial distress. Banks collect deposits from households, and provide loans to firms according to their size. Banks equate expenses and revenues. The deposit rates are controlled by the central bank, and the lending rates are chosen by the banks. To accommodate a credit crunch, the banks can allocate their assets to loans and risk-free fixed-income securities. We assume that banks have a risk-management practice that is linked to a benchmark loss/deposit ratio. Banks in this model have no capital, so minimum-capital adequacy requirements cannot be applied here. The benchmark loss/deposit ratio is derived from a benchmark case—the normal state of the economy. This ratio is binding when the economy is in a bad state in terms of returns. The model is able to generate a credit crunch such that banks will reallocate balance-sheet assets from loans to government securities and cause a reduction in lending activity.

The model is then used to analyze monetary policy. In our first experiment, we examine the effectiveness of monetary policy during a credit crunch. Given a half per cent decrease in deposit rates, bank lending rates are lowered by 40 basis points. Banks lend to some smaller firms, but they still hold a large proportion of their assets in government securities. In a second experiment, we allow banks to relax the loss/deposit ratio so that banks have the same bond/deposit ratio as in the benchmark case. We find that the loss/deposit ratio must be doubled. These results may imply that if a credit crunch is caused by regulations or by a too-conservative risk-management practice, monetary policy has very limited effects compared with relaxing the regulations or banks' risk-management practices.

In Section 1, we describe the model. In Section 2, the model is calibrated to the Canadian economy. In Section 3, we use this model to generate a credit crunch and analyze the implications for monetary policy. In the last section, we offer conclusions.

1 The Model

In this section, we develop a general-equilibrium model of financial intermediation.[1] There are three agents in this economy: households, banks, and a central bank. Households are endowed with a number of investment projects in each period. Because they are short of internal funds, households must apply to banks for external financing. The banks screen loan applications according to the applicants' net worth. Successful applicants become entrepreneurs, and others become workers. Each worker also faces an idiosyncratic shock for unemployment. Employed workers get labour income, and unemployed workers receive unemployment benefits.

Banks collect deposits and provide loans to entrepreneurs or purchase risk-free government bonds. Banks have a risk-management lending policy that may cause conservative lending in periods of reduced profitability and financial distress. The central bank has control over deposit interest rates, and adjusting deposit rates will influence banks' lending behaviour.

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[1] The curent model does not have aggregate shocks. Further extensions that include this type of shock may allow us to examine credit crunches over the business cycle.

1.1 Households

Households have a finite life expectancy. We denote the net worth of household i at period t as m_t^i. In each period, a household is endowed with n investment projects, x_t^{ij}, $j = 1, 2, \ldots, n$. Total investment is x_t^i $(=\sum_j x_t^{ij})$, and the investment for each project is x_t^i/n. The size of total investment is a fixed multiple ϕ of the current net worth of the household, m_t^i. If ϕ is above 1, then the household needs external financing. To simplify the problem, we assume that projects always need external financing:

$$x_t^i = \phi m_t^i \text{ with } \phi > 1 .$$

The returns on investment projects, r_t^j, are assumed to follow a normal distribution with mean r and standard deviation σ_r. r_t^j is drawn independently across all projects and individuals. Also, the returns face a positive probability of being sufficiently negative such that the bank faces losses from lending to some projects.

Households apply to banks for the extra funds needed to finance their investment projects. If loans applications are accepted by the bank, the household becomes an entrepreneur. The entrepreneur undertakes projects and receives the project returns. If the loan application is rejected, the household may become employed or unemployed, with given probabilities. Assume u to be the probability of being unemployed. The employed worker provides labour and receives labour income, y. The unemployed worker receives unemployment insurance benefits, θy, where θ is the replacement ratio. The remaining net worth is carried over to the next period.

In addition, being either an entrepreneur or a worker, each household faces a probability τ of forced retirement. After retirement, the household can earn income only from deposits and pensions. Finally, retirees face a probability δ of dying. They are then replaced by new agents with no assets. Remaining assets are lost (there are no bequests in the model).

The momentary utility function for workers, entrepreneurs, and retirees is

$$U^{oc}(c) = \frac{(\xi^{oc} c^{1-\rho})^{1-\rho} - 1}{1-\rho},$$

where oc is occupational choices and the set of oc is $\{W, U, E, R\}$, in which W, U, E, and R are employed workers, unemployed workers, entrepreneurs, and retirees, respectively. c is consumption, and σ and ρ are positive parameters. ξ^W, ξ^U, ξ^E, and $\xi^R > 0$.

Now we describe the value functions for each agent. We denote V^W, V^U, V^E, and V^R as the value functions of workers, the unemployed, entrepreneurs, and retirees. m^* is the minimum net worth eligible for external financing. A worker with net worth $m(< m^*)$ in the current period has probability $(1-u)$ of being employed.[2] Once employed, the worker gets labour income y, deposits his or her net worth in banks, and receives interest income, $R^d m$. The total income is then allocated to consumption, c, and savings, m'. If unemployed, the worker receives unemployment benefits, θy, and also deposits his or her net worth in banks. The total resources are also allocated to consumption, c, and savings, m'. In the following period, the worker faces a probability τ, of retiring. Otherwise, the worker may become an entrepreneur or remain a worker, depending on his or her net worth, m'.

For a worker,

$$V^W(m) = \max_{\{c^W, m'\}} \{U^W(c^W) + \beta[(1-\tau)[(1-u)V^W(m') + uV^U(m') + E_{r'} V^E(m', r')] + \tau V^R(m')]\}, \tag{1}$$

subject to

$$c^W + m' = (1+R^d)m + y,$$

$$V^W(m) = 0 \text{ if } m \geq m^*.$$

For an unemployed worker,

$$V^U(m) = \max_{\{c^U, m'\}} \{U^U(c^U) + \beta[(1-\tau)[(1-u)V^W(m') + uV^U(m') + E_{r'} V^E(m', r')] + \tau V^R(m')]\}, \tag{2}$$

subject to

$$c^U + m' = (1+R^d)m + \theta y,$$

$$V^U(m) = 0 \text{ if } m \geq m^*.$$

An entrepreneur invests in n projects and gets return r^j for project x^j for $j = 1, 2, \ldots, n$. He or she also receives labour income, y, and pays the borrowing cost, $R^l(x-m)$; what is left can be consumed or saved. The net wealth is constrained to be non-negative (this is a liquidity constraint). Project losses may, however, drive net wealth down to negative numbers, in which case the household consumes a minimal consumption allowance,

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[2] Since we use a yearly model and the duration of unemployment is below one year, u is not state-dependent.

c^{min} (funded by the banks), declares bankruptcy, and defaults on its debt.[3] In that case, the household starts next period with no assets and no liabilities. In the following period, the entrepreneur has a probability τ of retiring.

$$V^E(m,r) = \max_{\{c,m'\}} \{U^E(c) + \beta[(1-\tau)[(1-u)V^W(m') + uV^U(m') + E_{r'} V^E(m',r')] + \tau V^R(m')]\}, \tag{3}$$

subject to

$$c = \max\left\{c^{min}, m + y + \sum_{j=1}^{n} (1+r^j)x^j - R^l(i-m) - m'\right\},$$

$$\sum_{j=1}^{n} x^j = \phi m,$$

$$V^E(m,r) = 0 \text{ if } m < m^*.$$

Also, V^E, V^W, and V^U have to satisfy a participation constraint,

$$E_r V^E(m^*,r) \geq (1-u)V^W(m^*) + uV^U(m^*), \tag{4}$$

which implies that, at the margin, the household would prefer to be an entrepreneur (applying for a loan) rather than a worker.

Once a household retires, it receives pension income, y^R. The net worth and pension income are allocated to consumption and savings. In the following period, the household has a probability δ of dying.

$$V^R(m) = \max_{\{c,m'\}} \{U^R(c) + \beta[(1-\delta)V^R(m')]\}, \tag{5}$$

subject to

$$c + m' = (1+R^d)m + y^R.$$

One aspect of credit crunches that has been largely ignored in the literature is heterogeneity among both investment projects submitted and the methods used by banks to screen them. In this model, we introduce heterogeneity in several ways: individual unemployment risk; risk of project returns; and risk of the life cycle (retirement, death, and birth). Households are then heterogeneous along several dimensions: active or retired;

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[3] There is no moral hazard problem here, since banks constantly monitor the returns.

entrepreneur; worker or unemployed; and, most importantly for our question, wealth.

In this model, households have several motivations to accumulate assets: to save for retirement; to maximize returns through investment projects instead of deposits [participation constraint, constraint (4)] and to protect themselves against unemployment shocks that are imperfectly insured. Banks take the bankruptcy risk of their clients into account when they make loan decisions, so we need bankruptcy in this model. But bankruptcy is very tough on households: In one bad period, they lose all their accumulated assets and may, for example, jeopardize their retirement assets. For this reason, we have introduced the possibility of investing in several projects at a time, which spreads the risk.

1.2 Banks

The bank in our model accepts deposits from workers and retirees, and makes loans to entrepreneurs to finance investment projects. The deposit interest rate, R^d, is considered to be given by monetary policy. For projects that lose money, the bank pays an auditing fee, μ, to recover the salvage value of the project.

The bank chooses m^*, and the interest rate for loans, R^l, such that

(i) disbursements for deposits equal revenue from loans:

$$\sum_{m_t^i < m^*} R_t^d m_t^i = E_r\left\{ \sum_{m_t^i \geq m^*} R_t^l (x_t^i - m_t^i) - \sum_{m_t^i \geq m^*} L_t^i \right\} \\ + R_t^d \max\left\{0, \sum_{m_t^i < m^*} m_t^i - \sum_{m_t^i \geq m^*} (x_t^i - m_t^i)\right\}, \qquad (6)$$

in which losses are defined as:

$$L_t^i = \max\{0, (1+\mu)[(1+R_t^l)(x_t^i - m_t^i) - x_t^i(1+r_t^i)] + g_t^i\},$$

where g_t^i represents additional losses incurred if a household has to be granted its minimal consumption;

(ii) expected losses incurred from loans do not exceed a certain share, α, of the deposits,

$$E_r\left\{ \sum_{m_t^i \geq m^*} L_t^i \right\} \leq \alpha \sum_{m_t^i < m^*} m_t^i; \qquad (7)$$

(iii) banks cannot lend more than the value of deposits they have accepted,

$$\sum_{m_t^i \geq m^*} (x_t^i - m_t^i) \leq \sum_{m_t^i < m^*} m_t^i. \tag{8}$$

Through the households' choices of m^i and banks' choice of m^*, the total quantity of loans is determined endogenously. The left side of the equation represents the loans, and the right side of the equation represents the deposits that can be used for loans or bonds. Bonds represent safe assets used by the banks to reduce the loss/deposit ratio.

The loss/deposit ratio α can be interpreted in two ways. First, it can be linked to the internal risk management (a rule of thumb) and the value at risk (VaR). Second, it can be seen as an external regulatory constraint. Such a constraint is often related to capital-adequacy requirements. However, in this model banks have no capital. Nevertheless, the loss/deposit ratio can be converted to a loss/capital ratio.

Banks screen projects according to borrowers' net worth. Because investment projects earn significantly higher expected returns than do deposits, each household would like to be approved for a loan, which is necessary to run a project. Given that projects, and therefore loans, are proportional to the collateral provided by the household (its wealth), banks use household wealth to screen projects: Only projects backed up by collateral above a certain threshold are approved.

Other observations can back up this hypothesis: Many households have little wealth, and do not invest it in assets other than deposits. They may want to invest in profitable projects, but they know they will not be approved for credit. Also, when banks tighten credit rules, small businesses are most likely to suffer.

1.3 The central bank

The central bank's only influence is through setting the interest rate on deposits, R^d, which can be viewed as the stance of monetary policy and/or economic conditions.

How does the central bank affect bank lending behaviour? A private bank's lending policy involves two options: the cutoff point, m^*, for loans and the lending rate, R^l. If the central bank lowers the deposit interest rate, how would banks change their lending policy? If the banks fix one of these two options, then the answer is straightforward. When the lending cutoff point, m^*, is held fixed, a decline in banks' deposit cost will lower the lending rate accordingly, to equalize costs and revenues. Similarly, if the bank holds lending rates fixed, then profits will increase, and banks could lower m^*.

Moreover, if banks can adjust both variables, it would be difficult to determine the analytical consequences, because both R^l and m^* could be lowered or increased. In the next two sections, we attempt a quantitative analysis based on a calibrated model to address this question.

1.4 Computing steady-state equilibrium

In describing the computational procedure used to solve the model, we first define the equilibrium concept and then outline a procedure for finding the equilibrium. Let z be the set of parameters that describe the economy, a set that can be altered from the benchmark for computational experiments. An equilibrium is a collection of a loan interest rate, $R^l(z)$, a loan threshold, $m^*(z)$, a law of motion of the agents in the economy, $\lambda' = g(\lambda;z)$, and decision rules for households, $m^W(m;z)$, $m^U(m;z)$, $m^E(m, r;z)$, and $m^R(m;z)$, such that:

(i) households solve their optimization problems shown in equations (1), (2), and (3);

(ii) the banks break even, equation (6). Their loss/deposit ratio does not exceed the benchmark value α, constraint (7). And they cannot lend more than deposits accepted, constraint (8). The participation constraint, constraint (4), is also satisfied.

To solve for this equilibrium, we define a grid for all household types (worker, unemployed, entrepreneur, retired), asset levels, and project returns. For initial values of R^l and m^*, we computed utilities for all feasible decisions, and then calculated iteratively the value functions. Once optimal decision rules are determined, they are used, along with the laws of motion, to find the invariant distributions of households across types, asset levels, and project returns. Given this distribution, the banks' equilibrium constraints are evaluated. If they are not within a reasonable range, R^l and m^* are modified and the whole procedure starts again. Once everything has converged, we draw aggregate statistics.

2 Calibration: The Benchmark State

The model is calibrated to the Canadian economy according to annual data from 1988 to 1992, a period for which we have the distribution data of the return on equity (Statistics Canada 1994). Following the literature, ρ and β are set to 2.5 and 0.96, respectively. σ is set to 0.67. ξ^E, ξ^W, ξ^U, and ξ^R are set to be consistent with standard models with explicit leisure specification, i.e., $\xi^E = \xi^W = \xi^U = 0.55^{0.67}$, and $\xi^R = 1$, which implies that the working hours of employed workers and entrepreneurs and the search effort of the unemployed are set to 0.45. The labour income of workers and entrepreneurs, y, and the retirement income, y^R, are set at 1 and 0.3, respectively. The probability of retirement, τ, and the mortality rate of retirees, δ, are set at 5 per cent and 10 per cent, respectively.

Calculated from the real Guaranteed Investment Certificate rates and the real savings deposit rates, the deposit rate, R^d, is set at 1.00 per cent. The unemployment insurance benefit is 29.29 per cent of wage rates.[4] Minimum consumption is assumed to be the same as the unemployment benefit.

The investment/net worth ratio, ϕ, is calculated from the debt/equity (D/E) ratio. The average D/E ratio during the reference period is 1.2, which implies ϕ to be 2.2. The auditing fee, μ, is set at 6 per cent.

Statistics Canada (1994) reports the distribution of return on equity for non-financial enterprises from 1988Q4 to 1992Q4. For each quarter, the average returns on equity are reported for the top, middle, and bottom tertiles. For our model, we also use discrete-return distribution to simplify computation. The returns of projects are calculated from the return-on-equity data of firms by assuming normal distributions. During the period, this distribution implies discrete returns of $r = \{-50$ per cent, 4.52 per cent, 60 per cent$\}$ with probabilities of $\{0.0098, 0.9817, 0.0085\}$, respectively. The lowest return is chosen to generate occasional bankruptcies, the middle one to match the average return.

The lending rate, R^l, and the asset for the minimum qualified firm, m^*, are chosen such that banks equilibrate their income and disbursements and the bond/deposit ratio is close to the average of the bond-holding ratios over the reference period. The lending rate, R^l, is calculated to be 1.18 per cent, and m^* to be 6.76. In the benchmark steady state, the number of workers is 0.58, the number of entrepreneurs is 0.09, and the number of retirees is 0.33. With respect to the wealth distribution, the benchmark economy has a Gini coefficient of 0.65.

In this benchmark model, there are some loan losses for banks because of the possible negative returns. The loss/deposit ratio is found to be 0.166 per cent. We use this ratio as a benchmark for banks' lending policy. It turns out that, during periods of reduced return, this ratio becomes binding, which leads to banks' conservative lending behaviour and causes a credit crunch.

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[4] The measure is based on the replacement rate constructed in Hornstein and Yuan (1999). The following elements of unemployment insurance (UI) benefits are considered: the legislated replacement rate, the percentage of the labour force covered by UI (the coverage rate), the maximum number of benefit weeks for a minimally qualified claimant, and the minimum number of working weeks needed to qualify for UI.

3 Credit Crunch, Bank Lending Behaviour, and Monetary Policy

We now use this model to generate a credit crunch. The return-on-equity data show that firms' returns in 1992Q4 are less than the average of the reference period. We calculate the annualized return distribution according to 1992Q4. Our calculation suggests the returns of projects to be $r = \{-50$ per cent, 2.57 per cent, 60 per cent$\}$ with probabilities $\{0.0179, 0.9742, 0.0079\}$. The unemployment rate in the reference period is 11.57 per cent, and ϕ is 2.3. The deposit rate is set to be identical to the benchmark case, 1.00 per cent, so that we can examine the banks' lending behaviour during periods when banks see reduced profitability, but the central bank does not change its monetary policy stance.

To generate a possible credit crunch, we choose m^* and R^l, such that the bank loss/deposit ratio matches the benchmark case, 0.166 per cent, and banks equilibrate revenues and expenses.

In equilibrium, we find that the last qualified firm has asset m^* of 6.84; that size is larger than that of the benchmark case, 6.76 (see Table 1). This suggests that the banks have reduced loans to smaller firms. The total loans are reduced dramatically, by more than 60 per cent in the credit-crunch state, compared with the benchmark state. The lending rate is calculated to be 1.30 per cent, which is higher than the benchmark lending rate, 1.18 per cent. In the distribution of bank assets, we see a big increase in the ratio of bank deposits allocated to bonds. The ratio increases to 58 per cent compared with the benchmark result of 13 per cent. The restriction of the loss/deposit ratio effectively mimics the bank's conservative lending behaviour. This avoids explicitly modelling changes in bank risk-aversion in lending under different economic states.

We also find that more people become workers (0.64 compared with 0.58) and fewer become entrepreneurs (0.03 compared with 0.09). The Gini coefficient decreases to 0.62, compared with the benchmark case, 0.65, and the average utility decreases from –0.23 to –0.26 during this credit crunch.

In this state, bankruptcies occur more often because projects post lower returns and lending rates are higher. Banks are tied by their loan strategy and, as losses increase as a share of loans, banks must reduce the quantity of loans. As m^* is increased, some entrepreneurs become workers, which drives down the quantity of loans. The decrease in the number of loans is partially offset by the increase in the average size of the remaining

Table 1
Steady-state analysis

	Benchmark	Credit crunch	Monetary policy	Lending policy
Deposit rate, R^d	0.0100	0.0100	0.0050	0.0100
Return distribution	–0.5000 0.0098	–0.5000 0.0179	–0.5000 0.0179	–0.5000 0.0179
	0.0452 0.9817	0.0257 0.9742	0.0257 0.9742	0.0257 0.9742
	0.6000 0.0085	0.6000 0.0079	0.6000 0.0079	0.6000 0.0079
Cut-off point, m^*	6.76	6.84	6.55	6.72
Lending rate, R^l	0.0118	0.0130	0.0090	0.0140
Bonds/deposit (%)	13	58	57	14
Loss/deposit, α (%)	0.166	0.166	0.166	0.345
Total loans	0.76	0.27	0.26	0.80
Total deposits	0.87	0.65	0.60	0.92
Number of workers	0.58	0.64	0.64	0.58
Number of entrepreneurs	0.09	0.03	0.03	0.09
Number of retirees	0.33	0.33	0.33	0.33
Gini coefficient	0.65	0.62	0.62	0.64
Average utility	–0.23	–0.26	–0.27	–0.23

loans. This process continues until the banks find the m^* that yields the original loss/deposit ratio. Along the way, the banks must also modify the loan rate to recuperate the higher costs per loan due to losses.

3.1 Steady-state policy experiments

We now carry out a steady-state monetary policy experiment, in which the central bank lowers the deposit rate in the credit-crunch state. In this experiment, R^d is reduced by one-half per cent. We examine the changes in the banks' lending behaviour, i.e., how banks change R^l and m^*. Banks choose R^l and m^*, such that revenues equal expenses and the loss/deposit ratio matches the benchmark case (0.166 per cent).

Given a one-half per cent decrease in the deposit rate, bank lending rates are lowered by 40 basis points to 0.90 per cent. Banks increase their lending to small firms by reducing the cut-off point for lending, m^*, to 6.55 from the credit crunch level of 6.84. The bond-holding ratio remains the same as in the crunch case. The total deposit and total loans are reduced slightly. Overall, the effects of reduced deposit rates are quite limited.

Reducing interest rates is largely ineffective, because the banks are mostly constrained by their loss/deposit ratio, α. However, the interest rate change has various effects. Lower deposit rates give workers less incentive to save deposits. However, the banks have fewer interest payments to make, so they can reduce the loan rate to balance their books, thereby inciting some workers to opt for entrepreneurship. But all these effects are small.

To evaluate the relative effectiveness of this policy change, we conducted another experiment, in which banks relax their loss-control rule, i.e., the loss/deposit ratio, α, is increased. Banks choose m^* and R^l, such that revenues equal expenses and the bond/deposit ratio matches the benchmark case (13 per cent) as closely as possible. The last column of Table 1 shows that once the loss/deposit ratio α is increased to 0.345 per cent, about double the ratio in the benchmark case, the bond/deposit ratio is reduced to 14 per cent, which is close to the value in the benchmark case. Compared with the credit-crunch state, more people become entrepreneurs and fewer become workers. The average utility is restored to the same level as in the benchmark case.

This policy is much more effective, because it relaxes the most binding constraint on the banks. Indeed, although the loss/deposit ratio, α, increases, the banks are still able to balance their books with only a slight increase in loan rates. The lowering of m^* incites some workers to become entrepreneurs, and the impact of lower returns largely disappears: While projects have a lower average return than in the benchmark—without a credit crunch—they still have a higher return than do deposits. With more projects, the returns realized in the economy as a whole increase.

Conclusions

In this paper we have developed a dynamic general-equilibrium model of financial intermediation that is innovative in that it takes account of the heterogeneity of investment projects. Furthermore, the decision to become a loan-contracting entrepreneur is endogenous, and workers decide on deposits that the bank can use for loans and bonds. Given that projects and even individuals can go bankrupt in this model economy, banks take explicitly into account possible losses from loans. This self-regulation, which has recently been imposed on the banks by the Basle Accord, appears to be the determining factor in a credit crunch. Calibrated for the Canadian economy, our model finds that monetary policy can do little to ease a credit crunch that arises because of increasing loan risk. However, more flexible loans regulation, in particular, rules that allow the banks to take more losses that are compensated by higher loan rates, is very effective.

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Discussion

Emanuela Cardia

Yuan and Zimmermann construct a model that can generate "credit crunches," i.e., inefficient conservative lending, and examine whether monetary policy, loan regulation, or both, can reduce the impact of credit crunches. They find that, while loan regulation can eliminate the effects of a credit crunch, monetary policy can do little to alleviate the credit crunch itself.

The Yuan and Zimmermann paper is an interesting contribution to the literature on credit crunches. While several empirical papers have suggested that in the early 1990s Germany, Finland, the United States, and Japan were constrained by inefficient conservative lending, few have tried to develop a theoretical framework in which to examine this issue.

The authors use a general-equilibrium model with several types of households and heterogeneous projects. The most important type of heterogeneity comes from assuming that households can be workers if their net assets, m, are smaller than a certain critical level, m^*, a choice variable of the banking system, and that households can be entrepreneurs if $m \geq m^*$. A household will ask for lending if the desired project implies outlays greater than its net assets. Only if $m \geq m^*$ will the household see the project approved and become an entrepreneur. This set-up is essential for creating the possibility of credit crunches. The authors also assume that households retire with a fixed probability, τ, can be unemployed with a fixed probability, $1 - \mu$, and have a finite life expectancy. However, Yuan and Zimmermann do not explain how these additional sources of heterogeneity are essential to the study of credit crunches. From Table 1, I see that the number of retirees does not change across all experiments. Perhaps we would lose nothing by omitting this feature. If this is the case, I think that it would be best to omit retirement in the model and add a footnote to explain that nothing would change if we were to assume that households can retire.

The authors should discuss the channel in their model through which credit crunches may affect unemployment, and they should also report how unemployment changes across the different experiments. Again, I believe that if unemployment does not add much to the result it should be omitted. Finally, I don't understand how finite horizons can make a difference. Although these elements do generate different reasons for why people may save, they are not the focus of the paper. Unless they are shown to affect the results, they should not be included, as they dilute the contribution of the paper and render the model and results difficult to understand.

The banking system chooses the critical level, m^*, and the lending rate, R_l, and takes as given the rate on the deposit, R_d, and the loss/deposit ratio, α. This is where one important element of the lending inefficiency is introduced: α may not be optimal. The central bank sets the interest rate on deposits, R_d. There is another constraint, i.e., that m has to be greater than m^*. This is also a source of inefficiency, and is probably used to describe the idea that small projects have less chance of getting financed. The authors should discuss the sources of lending inefficiency in the model.

My main difficulty with the paper concerns the results. The results presented in Table 1 present four scenarios. The first is the benchmark case. The second is the credit-crunch case where returns are (exogenously) lower. The other two cases examine how monetary and lending policies could allow us to go from the credit-crunch situation to the benchmark one. The credit-crunch situation occurs because lending has decreased (from 0.76 to 0.27). However, even without inefficient lending, lending would have decreased in response to a drop in the projects' returns. The question is to know how much more lending has decreased because of inefficient lending. To know that, one would have to compare the situation with one in which there is no inefficient lending. I don't know whether this is feasible in the current set-up; however, it seems crucial to me to know the contribution of the lending inefficiency versus the effects on lending due to lower returns. When the policy experiments are examined, the authors compare the results of the policies with the benchmark case. However, returns were higher in the benchmark case. The paper's objective was to examine the role of monetary and lending policies in alleviating the effects of credit crunches, not the effects of reduced profitability. The objective should be redefined or the policy experiment clarified. I would also like to see the effects of reduced profitability on m and y.

Discussion

Shouyong Shi

Yuan and Zimmermann pose the following question: Can monetary policies help the economy recover from a credit crunch? Their answer is: Not much, if banks manage risks conservatively by imposing an upper bound on the loan loss/deposit ratio. In fact, if the central bank cuts the deposit rate during a credit crunch, the total deposits and total loans fall. Therefore, easing monetary policies during a credit crunch is counterproductive.

The authors reached this conclusion by calibrating a dynamic general-equilibrium model with credit market imperfections. They took the year 1992 as one of a credit crunch relative to the sample period, 1988–92, and assumed that a negative shock to borrowers' project returns generated the crunch. The authors computed how the equilibrium would change if the central bank cut the deposit rate by one-half per cent during the crunch. The effects are as follows. Bank lending rates would fall, and banks would increase their lending standards. However, the total deposits and total loans would fall, both by small magnitudes.

To demonstrate how the model generates these results, let me briefly describe the model. It has one private bank and many agents. Agents are grouped into employed workers, unemployed workers, entrepreneurs, and retirees. At the beginning of each period, all agents, except retirees, can apply for loans, but only those who have enough wealth get loans. If an agent obtains a loan, he/she becomes an entrepreneur and invests the funds in projects. Otherwise, the agent becomes employed, unemployed, or retired, and deposits some of the wealth at the bank. The bank pools all of the deposits and makes loans, taking the deposit rate as given. The loan decisions are the lending rate and the lending standard, a cut-off level of borrowers' wealth above which a loan is provided. The bank balances its books, i.e., to equate the expected revenue from loans and the interest payment on deposits.

In this model, agents are rationed if their wealth levels are below the lending standard. Such credit rationing is generated by three imperfections of the loan market, highlighted in the following assumptions:

(A1) Borrowers have limited liability—their consumption cannot be negative—and so the bank cannot recover the loan when a project has a sufficiently low return.

(A2) For each unit of a loan loss, the bank must incur an additional cost and may also provide a minimum consumption level for the bankrupt agent.

(A3) The bank is conservative in lending—it imposes an upper bound on the loan loss/deposit ratio, α.

These imperfections compel the bank to set a lending standard above agents' lowest wealth. While the first two imperfections are standard in credit-rationing models, the last is relatively new, and is critical for a credit crunch.

A credit crunch occurs in the model as follows. When there is a negative shock to entrepreneurs' project returns, the expected revenue from loans falls. More borrowers declare bankruptcy and, by (A1) and (A2), the bank faces a higher loan loss. To balance the books, the bank increases the lending rate and the lending standard. The loan market becomes tighter and, in particular, more small (poor) borrowers are squeezed out. The loan market becomes tighter in this way even without the conservative lending constraint, (A3), but this tightening might not be large enough to constitute a credit crunch. A credit crunch occurs when the bank further increases the lending standard and greatly reduces the loan supply to meet the conservative lending constraint.

I like the following two aspects of the model. First, it has a general-equilibrium flavour and is dynamic—each agent lives for quite a long time. The long lifetime and the general-equilibrium feature allow the authors to fully incorporate how loan market imperfections affect consumption and savings and how these effects in turn affect the loan market through deposits. In contrast, most other models allow agents to live for only two periods, and thus the loan market imperfections do not have a strong feedback effect through savings (e.g., Williamson 1987, and Bernanke and Gertler 1989).

Second, loan applicants are endogenously divided into entrepreneurs and depositors, according to their wealth: Rich applicants are entrepreneurs and poor applicants are depositors. There is even a wealth distribution among entrepreneurs. This modelling approach not only makes loan supply and demand endogenous, but also allows a credit crunch to generate distributional effects. For example, poor and small borrowers suffer the most in a credit crunch, since they are the first ones to be rationed when the lending standard increases. Agents are also heterogeneous in other ways. Some are employed and some are not; some are in the labour force and others are retired. Thus, the current model is useful for addressing both the aggregate effects and the redistributional effects of credit market policies.

Now, let me offer some criticisms on the paper.

The authors should explain more clearly why conservative lending can generate a credit crunch. The model appears to have picked up a strong negative wealth effect on depositors, which reduces loans through the conservative lending constraint. In the model, total loans fall from 0:76 in the sample to 0:27 in 1992, accompanied by only a small increase in the lending standard (from 6:76 to 6:84), but by a large drop in deposits (from 0:87 to 0:65). This drop is responsible for the sharp increases in the bank's bond holdings/deposit ratio (from 13 to 58) and in the lending rate (from 1:18 per cent to 1:30 per cent). In this sense, the credit crunch in the model is more precisely a deposit crunch.

This is how the conservative lending constraint is important for the credit crunch. When entrepreneurs' wealth falls after a negative shock to project returns, the bank is severely restricted by the conservative lending constraint, for two reasons. First, those entrepreneurs who are lucky enough to be entrepreneurs again in the future will require more external financing, which increases the expected loan loss. Second, and more important, those who cease to be entrepreneurs in the future save less and deposit less. The two effects both increase the loss/deposit ratio and, to maintain the conservative lending constraint, the bank greatly reduces loans. My guess is that such a credit crunch will occur in the model even when the bank's lending standard does not change.

The behaviour of deposits might also explain why a lower deposit rate does not help the economy to recover. In fact, it further reduces depositors' wealth and makes loans even more difficult to obtain. As the numerical exercises indicate, when the central bank reduces the deposit rate by one-half per cent, total deposits and total loans both fall in spite of the fact that the lending rate and the lending standard both decrease. Since a negative shock to project returns generates a credit crunch by greatly reducing deposits, the monetary authority should increase rather than decrease the deposit rate during a credit crunch.

The authors did not explicitly outline why banks are conservative in lending, although they offered several reasonable explanations. Since the main results of the paper depend so much on this conservative lending constraint, one cannot help but wonder about such an exogenous restriction on the bank's behaviour. How can we be sure that the upper bound on the loan loss/deposit ratio does not change during a credit crunch? More important, how can we be certain that the bound does not react to monetary policies? By maintaining an exogenous lending constraint, the authors cannot be confident in the policy evaluation.

To illustrate this point, consider the explanations that the authors provided for the conservative lending constraint. One concerns the bank's assessment of the value at risk; the other concerns capital-adequacy requirements. Both explanations suggest opposite adjustments in the upper bound on the loss/deposit ratio during a credit crunch. If the bank is conservative in lending because of the value at risk, the negative shock to project returns increases the value at risk per unit of loan and induces the bank to become more conservative. That is, the bank should reduce the upper bound on the loss/deposit ratio. In this case, the shock generates a more severe credit crunch than in the model. On the other hand, if the bank is conservative because of the capital requirement, the reduction in loans during a credit crunch should make the bank less conservative. This is because the bank holds government bonds the value of which does not change during the credit crunch in the current model. With fewer loans, the bank can still meet the capital requirement if it increases the upper bound on the loss/deposit ratio. The conservative lending constraint becomes less binding in this case, and the credit crunch less severe.

Monetary policies have different effectiveness in these two cases. If the value at risk is the reason for the upper bound on the loan loss/deposit ratio, the central bank can achieve little by reducing the deposit rate. But if the capital requirement is the reason for the upper bound, an expansionary monetary policy can reduce the interest rate, increase the value of government bonds, and make the capital-adequacy requirement less binding. In this case, the policy induces the bank to increase the upper bound on the loss/deposit value and greatly mitigates the credit crunch.

There is a wide range of heterogeneity in the model, but the authors did not fully explore it. As mentioned, this wealth of heterogeneity allows a credit crunch to have redistributional effects. The authors mentioned only one that was already in the literature, i.e., a credit crunch hurts small entrepreneurs more than large entrepreneurs. But the authors can explain much more with this model. How does a credit crunch redistribute wealth between entrepreneurs and depositors? Are employed and unemployed workers affected differently? How do monetary policies redistribute wealth among agents?

Even if the authors are not interested in redistributional effects, they can still help us understand which heterogeneity is important for the aggregate effects. For example, this model includes unemployment, which is absent in previous models with credit rationing. It is interesting to find how important unemployment is for the aggregate behaviour of the loan market. My guess is that unemployment contributes very little to the credit crunch. This is because, as argued above, the crunch is driven primarily by the large fall in deposits, which can occur even if everyone is employed.

In summary, the authors undertook the challenging task of modelling a credit crunch in a dynamic general-equilibrium environment. They found that banks' conservative lending behaviour was critical for a credit crunch. The model is useful for evaluating both the aggregate and redistributional effects of a credit crunch and monetary policies. Although banks' conservative lending behaviour needs to be explicitly modelled, this paper is a good beginning in our understanding a credit crunch.

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General Discussion

Immediately after discussants Emanuela Cardia from the University of Montreal and Shouyong Shi from Queens University delivered their respective comments on the paper entitled "Credit Crunch, Bank lending and Monetary Policy: A model of Financial Intermediation with Heterogeneous products", the floor was open to questions and comments.

A few of the visiting participants from the Federal Reserve Bank spent time reiterating how to go about properly modelling a credit crunch and urged the authors to clearly outline this procedure in their paper. Others suggested that lending policy implications such as the returns on projects could have been pursued further. Finally, under the heading of policy advice implications, it was noted that although in a dynamic situation it made sense to deal with a credit crunch by easing policy, in a static situation the solution obtained may not be an attractive one. These comments offered additional in sights and extensions to the paper under discussion.

Several specific and technical questions were posed. For instance, discussant Shouyong Shi as well as audience members, questioned as to why the authors used so many different sources of heterogeneity in their model. Zimmerman in response to this, stated it was done in an attempt to construct a real world model, a model representative of the Canadian context capable of yielding meaningful results. Furthermore, having noted the authors use of heterogeneous agents, a conference participant then sought information on how they calibrated the distribution of returns, robustness and conducted sensitivity analysis.

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* Prepared by Andrea Losier.

Finally, a couple participants suggested and the authors agreed, that the calibration of various numbers such as screening costs and unemployment insurance benefits needed to be outlined more clearly in the paper.

The Expectations Trap Hypothesis

Lawrence J. Christiano and Christopher Gust

Introduction and Summary

Many countries, including the United States, experienced a costly, high inflation in the 1970s. This article reviews some research devoted to understanding why it happened and what can be done to prevent it from happening again.

We take it for granted that the high inflation was the result of high money growth produced by the U.S. Federal Reserve. But, to make sure that it does not happen again, it is not enough to know who did it. It is also necessary to know *why* the Fed did it. We hypothesize that the Fed was in effect pushed into producing the high inflation by a rise in the inflationary expectations of the public. In the language of Chari, Christiano, and Eichenbaum (1998), we say that when a central bank is pressured to produce inflation because of a rise in inflation expectations, the economy has fallen into an *expectations trap*. We call this hypothesis about inflation the expectations trap hypothesis.

We argue that the dynamics of inflation in the early 1970s are consistent with the expectations trap hypothesis. We describe two versions of this hypothesis. We also describe an alternative hypothesis, which we call the Phillips curve hypothesis. According to this hypothesis, inflation occurs when a central bank decides to increase money growth to stimulate the

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* This is a later version of the paper presented, under the title "The Great Inflation of the 1970s," at the conference. It is also published in the Federal Reserve Bank of Chicago's *Economic Perspectives*, Second Quarter 2000, 25 (2): 21–39.

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economy and is willing to accept the risk of high inflation that that entails. The expectations trap hypothesis and the Phillips curve hypothesis both maintain that high inflation is a consequence of high money growth. Where they differ is in the motives that they ascribe to the central bank.

Much of our analysis assessing the various hypotheses about inflation is based on an informal review of the historical record. We supplement this discussion by studying a version of the expectations trap hypothesis using a general-equilibrium, dynamic macroeconomic model. There are two reasons that we do this. First, we want to demonstrate that the expectations trap hypothesis can be integrated into a coherent view of the overall macroeconomy.[1] Second, we want to document that that hypothesis has the potential to provide a quantitatively realistic account for the 1970s takeoff in inflation.

The model we use is the limited-participation model studied in Christiano and Gust (1999).[2] It requires a specification of monetary policy in the 1970s, and for this we use the policy rule estimated by Clarida, Galí, and Gertler (1998). The account of the early 1970s that we produce using the model posits that a bad supply shock (designed to capture the various commodity shortages of the early 1970s) triggered a jump in expected inflation, which then became transformed into higher actual inflation because of the nature of monetary policy. We find that, consistent with the data, the model predicts stagflation. We view this result as supportive of the expectations trap hypothesis.

We compare our model with an alternative quantitative model of the 1970s inflation proposed by Clarida et al. That model can also explain the rise in inflation in the 1970s as reflecting a self-fulfilling increase in inflation expectations. It is a sticky-price, rational-expectations version of the IS-LM model.[3] When we use that model to simulate the 1970s, we find that it is inconsistent with the observed stagflation of the time. It predicts that the rise in expected and actual inflation triggered by a bad supply shock is associated with a sustained *rise* in employment. We conclude that the limited-participation model provides a better account of the high inflation of the 1970s than does the sticky-price, IS-LM model with Clarida et al.'s representation of policy. This result is potentially of independent interest, since the latter model is currently in widespread use.

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[1] Also, see Chari, Christiano, and Eichenbaum (1998).

[2] This model is a modified version of the model in Christiano, Eichenbaum, and Evans (1998).

[3] The model is derived from a dynamic general-equilibrium model with maximizing agents and cleared markets. The possibility that such a model could, under the sort of policy estimated by Clarida et al. using data from the 1970s, have an equilibrium in which inflation expectations can be self-fulfilling was first discovered by Kerr and King (1996).

We begin with a description of the expectations trap hypothesis and what it implies for policy. Then, we review the 1960s and 1970s and provide an informal assessment of the expectations trap and Phillips curve hypotheses. We provide a quantitative evaluation of the expectations trap hypothesis using the limited-participation model as a vehicle. We then provide an assessment of the Clarida et al. model.

1 What Is an Expectations Trap?

We begin with an abstract definition of an expectations trap. We then describe two particular types of expectations traps. Finally, we ask, What is the ultimate cause of inflation under the expectations trap hypothesis?

1.1 The trap, defined

An expectations trap is a situation in which an increase in private agents' expectations of inflation pressures the central bank into increasing actual inflation.[4] There are different mechanisms by which this can happen. However, the basic idea is always the same. The scenario is initiated by a rise in the public's inflation expectations. Exactly why their inflation expectations rise doesn't really matter. What does matter is what happens next. On the basis of this rise in expectations, private agents take certain actions which then place the Fed in a dilemma: either respond with an accommodating monetary policy which then produces a rise in actual inflation or refuse to accommodate and risk a recession. A central bank that is responsive to concerns about the health of the economy could very well wind up choosing the path of accommodation, that is, falling into an expectations trap.

1.2 A cost-push trap and a working capital trap

We describe two versions of the expectations trap hypothesis, which differ according to the precise mechanism by which higher inflation expectations pressure the Fed into supplying more inflation. One mechanism, presented in Chari, Christiano, and Eichenbaum (1998), is similar to the conventional *cost-push* theory of inflation. We call it a cost-push expectations trap. Here is how it works. Higher inflation expectations lead people to demand, and receive, higher wage settlements. Firms are happy to pay the increased wages because, expecting a rise in the general price level, they think they can pass along the higher wage costs in the form of higher prices. This puts the Fed in the dilemma mentioned above. The Fed can produce the inflation everyone expects by raising money growth. Or, if it does not, it will put the economy through a recession. Under some circumstances, the Fed will not be willing to tolerate the recession and will feel compelled to produce inflation. In this case, the Fed ends up validating the original rise in inflation expectations. We call this hypothesis about inflation, the cost-push version of the expectations trap hypothesis.[5]

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[4] In this paper, we focus on expectations traps in which inflation is high. The opposite—an expectations trap in which inflation is low—is also a possibility.

We shall see that this version of the expectations trap hypothesis encounters some difficulties explaining the high inflation of the 1970s. We now describe another version of this hypothesis, which does not have these problems.

The limited-participation model of money, which is analyzed below, highlights a different mechanism by which an expectations trap can occur. We call this a *working-capital* expectations trap. It relies on the assumption that firms must borrow funds in advance (acquire working capital) in order to finance some or all of the inputs needed to carry on production. Under these circumstances a high nominal interest rate has a negative impact on economic activity because it raises the cost of working capital. To see how this mechanism works, suppose, again, that there is a jump in inflation expectations. Private agents, correctly perceiving that the central bank is afraid of the negative output effects of high interest rates, anticipate that the higher future inflation will be associated with low real interest rates. This leads them to cut back on saving, putting upward pressure on interest rates in the market for loanable funds. This places the central bank in a dilemma. If it keeps the money supply unchanged, then the higher expected inflation will not occur. However, the reduced saving would result in high interest rates. By drying up the supply of working capital, this would significantly slow the economy. A central bank that is concerned about the health of the private economy may prefer a second option: prevent a substantial rise in interest rates by injecting money into the economy. This has the effect of validating the initial jump in inflation expectations. Choosing this second option is another way to fall into an expectations trap. We call this hypothesis about inflation the working-capital version of the expectations trap hypothesis.

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[5] The cost-push expectations trap is very close to the hypothesis Blinder advances as an explanation of the takeoff of inflation in the early 1970s:

> Inflation from special factors can "get into" the baseline rate if it causes an acceleration of wage growth. At this point policymakers face an agonizing choice—the so-called accommodation issue. To the extent that aggregate nominal demand is *not* expanded to accommodate the higher wages and prices, unemployment and slack capacity will result. There will be a recession. On the other hand, to the extent that aggregate demand *is* expanded (say, by raising the growth rate of money above previous targets), inflation from the special factor will get built into the baseline rate. (Blinder 1982, 264)

1.3 Ultimate cause of inflation

Where, under the expectations trap hypothesis, does the ultimate responsibility for inflation lie? To answer this requires identifying the *cause* of the rise in inflation expectations. According to the expectations trap hypothesis, the cause lies with monetary institutions themselves. If, for example, the nature of those institutions is such that people cannot imagine a set of circumstances in which the central bank would accommodate a rise in inflation, then there is little reason for inflation expectations to suddenly jump. Expectations traps just couldn't happen.

To see this, imagine there is an oil shortage. Certainly, one might reasonably expect this to lead to a rise in the price level. Because of various lags, this rise might actually take place over a period of time, maybe even a year or two. But, there is nothing in conventional economic reasoning that would connect an oil shortage to the sustained, decade-long rise in prices that we call inflation. Anyone who inferred from a 10 per cent jump in the price level in one year that prices would continue jumping like this and be 100 per cent higher in ten years, would be viewed as a crank. Such a person would seem as foolish as the person who, seeing the temperature outside drop one degree from one day to the next, forecasts a drop in the temperature by 100 degrees over the next 100 days.

Now consider an economy whose monetary institutions are known to assign a high priority to output and employment. In addition, suppose that that economy's central bank has no way of credibly committing itself in advance to keeping money growth low. In a society like this, the idea that inflation could take off seems quite plausible. In such a society, even seemingly irrelevant events could spark a rise in inflation expectations. For example, a person who revised upward their inflation forecast in the wake of an oil shock would now not necessarily seem like a crank. There are a number of ways they could back up their forecast with sensible economic reasoning. Such a person could use either of the two expectations trap arguments described above.

So, the expectations trap hypothesis lays responsibility for inflation with monetary institutions. To reduce the possibility of expectations traps, the institutions must be designed so that the central bank's commitment to fighting inflation is not in doubt. Under these circumstances, people participating in wage negotiations who profess to believe inflation is about to take off will be met with disbelief rather than a higher wage settlement.

How exactly monetary institutions should be designed to reduce the likelihood of an expectations trap is controversial. But, there is one point on which there appears to be agreement. The central banker at the very least should make a show of not being too concerned about the health of the economy. An example of this can be found in the reaction to a famous (or infamous) speech by the then vice-chairman of the Federal Reserve, Alan Blinder, at a conference in Jackson Hole, Wyoming, in 1994. In that speech, Blinder acknowledged that it is feasible for a central bank to influence unemployment and output. This generated an uproar. Many who objected probably did not do so because they thought what Blinder said was wrong. Instead, they simply thought it unwise that a central banker should let on that he thinks about such things.[6] Why shouldn't he let on? One possibility—the one emphasized in the expectations trap hypothesis—is that the greater the apparent concern by the central bank for the real economy, the greater is the risk of falling into an expectations trap.

2 Background Events

We provide a brief review of the basic economic events leading up to the high inflation of the 1970s. We argue that the data appear consistent with the hypothesis that the United States became ensnared in an expectations trap by the late 1960s and early 1970s. We then compare the expectations trap hypothesis about inflation with another hypothesis. According to that hypothesis, the Fed consciously produced the high inflation as a necessary, though unfortunate, by-product of its aggressive attempts to stimulate the economy. We call this the *Phillips curve hypothesis*, because it involves the Fed's attempts to exploit the Phillips curve. Finally, we look at the data to identify the economic consequences of the takeoff in inflation in the early 1970s.

2.1 Events leading up to the 1970s: Setting the trap

An important part of the story of the inflation of the 1970s begins with the recession of the early 1960s. That recession helped bring the administration of John F. Kennedy into power. Kennedy brought with him the best and the brightest Keynesian minds of the time. The chairman of the Council of Economic Advisers (CEA) was the very distinguished Keynesian economist, Walter Heller. Members of the CEA included another distinguished Keynesian economist, the future Nobel laureate, James Tobin. Government policy was animated by the Keynesian conviction that if the economy was performing below its potential, then it was the responsibility of the government to use the fiscal and monetary policies at its command to restore it to strength. Figure 1 displays the federal funds rate and the growth rate of the monetary base, using annual data. Also exhibited are the years designated by the NBER to be periods of business cycle contraction (shaded area) and expansion (non-shaded area).[7] The figure shows that the growth rate in the monetary base began to pick up in the early 1960s. The CEA also set to work to craft an expansionary fiscal policy, and one of the products of those efforts was the tax reduction legislation of 1964. Confidence in the feasibility and desirability of Keynesian stabilization policy soared with the long expansion of the 1960s.

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[6] For one prominent commentator who takes this position, see Barro (1996, 58–60).

Figure 2 shows that inflation started to pick up with a few years' delay, in 1965.[8] As these observations suggest, that initial rise in inflation is probably not an example of an expectations trap. It is probably best understood in terms of the Phillips curve hypothesis: It was the consequence of expansionary monetary policy, deliberately undertaken to stimulate a weak economy. It is the dynamics of inflation after the initial uptick in the 1960s that appears to take on the character of an expectations trap.

Figures 1 and 2 show that inflation proceeded to hit three peaks, one in the early 1970s, one in early 1975, and the final one in late 1980. The initial pickup in inflation in the 1960s was noted with alarm by policy-makers, who responded with a very sharp rise in the federal funds rate in 1969. This policy tightening is often credited with producing the 1970 recession. Policy-makers expressed dismay that the inflation rate continued to be high, even as the economy began to slide into recession (see Figure 1). Arthur Burns, the chairman of the Federal Reserve at this time, said in a speech at Pepperdine College, Los Angeles, on 7 December 1970:

> The rules of economics are not working in quite the way they used to. Despite extensive unemployment in our country, wage rate increases have not moderated. Despite much idle industrial capacity, commodity prices continue to rise rapidly. (Burns 1978, 118)

The policy establishment became convinced that the underlying driving force of inflation was inflation expectations and that these expectations were all but impervious to recession. In a statement before the Joint Economic Committee of the U.S. Congress in 1971, Burns explained the role of inflation expectations as follows:

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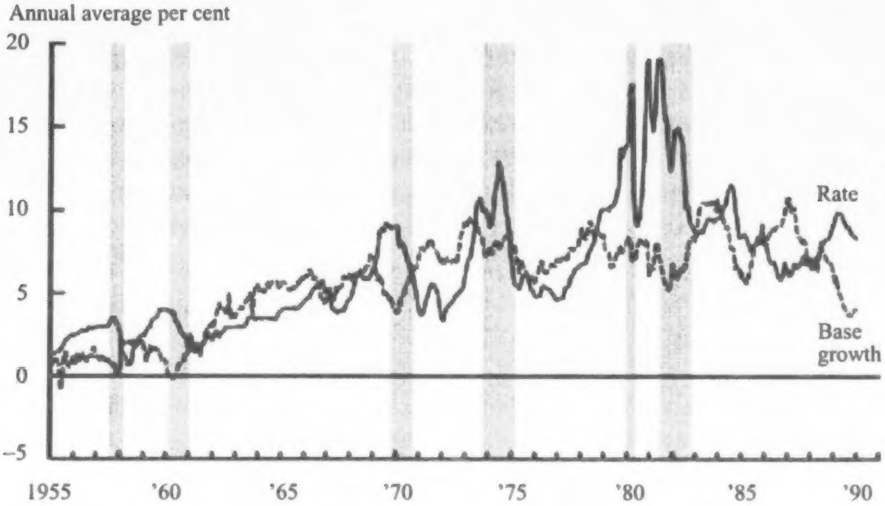
[7] The data are taken from Citibase. The mnemonic for the federal funds rate is fyff, and the mnemonic for the monetary base is fmbase.

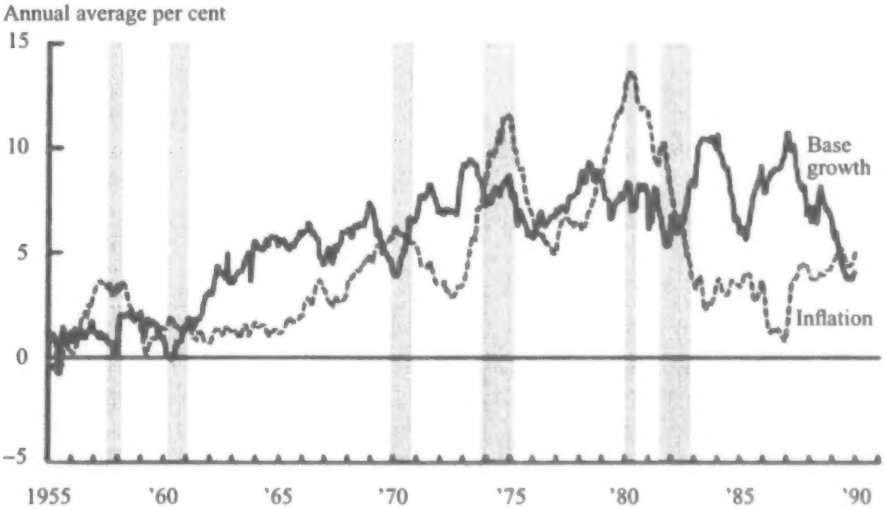
[8] Inflation is measured as the annual per cent change in the consumer price index with Citibase mnemonic, prnew (CPI-W: all items).

Figure 1
Base growth and federal funds rate



Note: Shaded areas indicate NBER-dated recessions.
Source: Based on data from Citibase.

Figure 2
Base growth and inflation



Notes: Shaded areas indicate NBER-dated recessions.
Inflation is measured as the annual per cent change in the CPI with Citibase mnemonic, *prnew* (CPI-W: all items).
Source: Based on data from Citibase.

> Consumer prices have been rising steadily since 1965—much of the time at an accelerating rate. Continued substantial increases are now widely anticipated over the months and years ahead. . . . [I]n this environment, workers naturally seek wage increases sufficiently large . . . to get some protection against future price advances. . . . [T]houghtful employers . . . reckon, as they now generally do, that cost increases probably can be passed on to buyers grown accustomed to inflation. (Burns 1978, 126)

Policy-makers understood that, in principle, inflation could be stopped with a sufficiently restrictive monetary policy, but they were concerned that the short-run costs, in terms of lost output, would be intolerable. In an appearance before the House of Representatives, Committee on Banking and Currency, 30 July 1974, Burns said:

> One may therefore argue that relatively high rates of monetary expansion have been a permissive factor in the accelerated pace of inflation. I have no quarrel with this view. But an effort to use harsh policies of monetary restraint to offset the exceptionally powerful inflationary forces of recent years would have caused serious financial disorder and economic dislocation. That would not have been a sensible course for monetary policy. (Burns 1978)

In remarks before the Seventeenth Annual Monetary Conference of the American Bankers Association, Hot Springs, Virginia, 18 May 1970, Burns elaborated on his views about the costs of relying on money growth alone (without, say, wage and price controls) to reduce inflation. He thought the costs were so large that the strategy was fundamentally infeasible on political grounds. In his words,

> There are several reasons why excessive reliance on monetary restraint is unsound. First, severely restrictive monetary policies distort the structure of production. General monetary controls, despite their seeming impartiality, have highly uneven effects on different sectors of the economy. On the one hand, monetary restraint has relatively slight impact on consumer spending or on the investments of large businesses. On the other hand, the homebuilding industry, state and local construction, real estate firms, and other small businesses are likely to be seriously handicapped in their operations. When restrictive monetary policies are pursued vigorously over a prolonged period, these sectors may be so adversely affected that the consequences become socially and economically

> intolerable, and political pressures mount to ease up on the monetary brakes. . . .
>
> An effort to offset, through monetary and fiscal restraints, all of the upward push that rising costs are now exerting on prices would be most unwise. Such an effort would restrict aggregate demand so severely as to increase greatly the risks of a very serious business recession. If that happened, the outcries of an enraged citizenry would probably soon force the government to move rapidly and aggressively toward fiscal and monetary ease, and our hopes for getting the inflationary problem under control would then be shattered. (Burns 1978)[9]

Policy-makers were so pessimistic about the prospects of getting inflation under control by restrictive monetary policy, that in August 1971 they turned to wage and price controls.

What happened after this may seem to be an embarrassment to the expectations trap hypothesis, particularly the cost-push version: Money growth continued to be high.[10] According to the cost-push expectations trap hypothesis, high money growth is the Fed's response to inflationary wage and price contracts, which are themselves driven by inflation expectations. But, inflationary wage and price contracts became illegal during the wage and price control period, which lasted until 1973. So, this hypothesis seems to predict that money growth would have been low during the wage-price controls, not high.[11]

The key to reconciling the expectations trap with this high money growth lies in interest rates. Policy-makers were convinced that wage-price controls would not be politically feasible if interest rates were allowed to drift up. They thought that if this happened, the controls would be viewed as a cover for redistributing income from people earning wages and salaries to the (typically wealthy) people who earn interest. They feared that if this happened, then political support for the controls would evaporate, and inflation would take off again. So, policy was directed toward keeping the nominal interest rate about where it was before the severe monetary tightening of 1969 (see Figure 3). It is interesting that it required such strong money growth to keep the interest rate at this level. A possible explanation is that this reflects the type of portfolio decisions emphasized in the working-capital expectations trap hypothesis described earlier. That hypothesis predicts that, in the absence of high money growth, household portfolio decisions motivated by concerns about future inflation would drive up the rate of interest.

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[9] In the same speech, Burns showed some foresight in warning about another danger associated with the strategy of relying on reduced money growth to stop inflation. He was concerned that the nature of the lags in monetary policy was such that the variance of inflation and money growth would go up in a "stop-and-go" process.

> [T]he effects of monetary restraint on spending often occur with relatively long lags. . . . Because the lags tend to be long, there are serious risks that a stabilization program emphasizing monetary restraint will have its major effects on spending at a point in time when excess demand has passed its peak. The consequence may then be an excessive slowdown of total spending and a need to move quickly and aggressively toward stimulative policies to prevent a recession. Such a stop-and-go process may well lead to a subsequent renewal of inflationary pressures of yet greater intensity. (Burns 1978)

[10] Money growth in 1970–74 was 5.32 per cent, 7.60 per cent, 7.27 per cent, 8.75 per cent, and 7.99 per cent, respectively. The number for period t is $100 \times \log(m(t)/m(t-1))$, where $m(t)$ denotes the monetary base, $t = 1970, 1971, 1972, 1973,$ and 1974.

[11] We address the potential for the Phillips curve hypothesis to explain high money growth during the period of wage-price controls in the next subsection.

These considerations suggest to us that although the high money growth during wage-price controls may well be an embarrassment to the expectations trap hypothesis, it isn't necessarily so.

Policy-makers started dismantling wage-price controls in 1973. They were once again surprised by the strength with which inflation took off. They had anticipated some inflationary pressure, and they raised rates sharply in this period (see Figure 3). But, they were surprised at just how strong the rise in inflation was.[12] The increase in rates was greater than one measure of the rise in expected inflation (see Figure 3). And, it just barely kept up with actual inflation (Figure 4).[13] Policy-makers' resolve began to fade when output and investment started to show weakness in the middle of 1973 and hours worked began to soften in late 1973. They had indicated repeatedly that they were unwilling to countenance a severe recession in the fight against inflation. Their concerns about the recessionary costs of fighting inflation seemed credible since they appeared to have been confirmed by the experience of the 1970 recession. Moreover, the 1960s and

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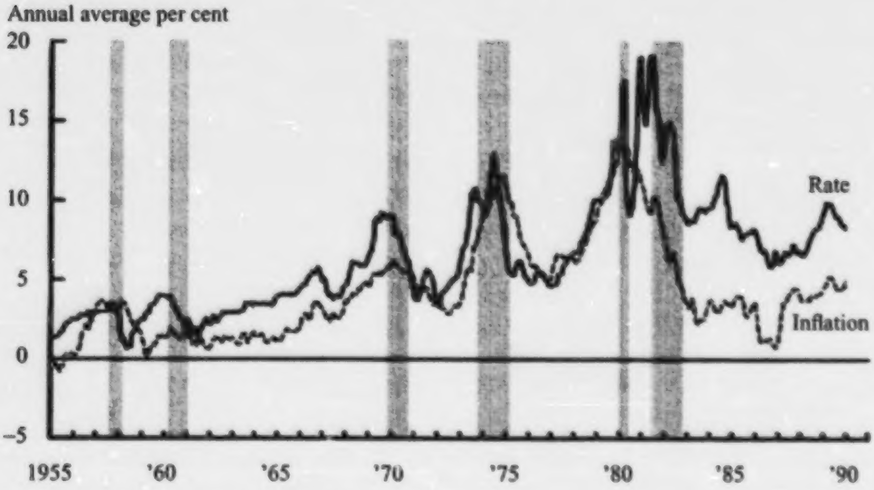
[12] To some extent, the rise in inflation was due to the oil shock in late 1973. However, about three-quarters of the price increases of that year occurred before the Yom Kippur War and the October oil embargo. The takeoff in inflation in 1973 may, in part, have reflected the delayed response of prices to the high money growth that occurred during the period of wage-price controls. We attempted to estimate what fraction of the 1973 price rise reflected past money growth, but found that statistical uncertainty is too large to draw a definite conclusion.

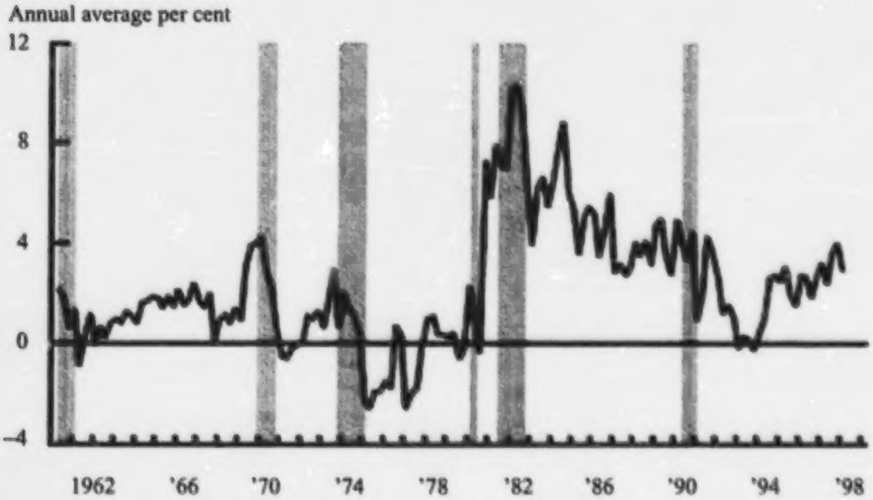
[13] We calculated expected inflation for Figure 4 based on a 1-month-ahead forecast of monthly CPI inflation using 5-month lags in monthly inflation, 4-month lags in the federal funds rate, 4-month lags in the monthly growth rate in M2, and 4-month lags in the premium in the return to 10-year Treasury bonds over the federal funds rate. The rise in real rates reported in Figures 4 and 5 would have been somewhat larger if we had used the GDP deflator to measure inflation.

Figure 3
Federal funds rate and inflation



Note: Shaded areas indicate NBER-dated recessions.
Source: Based on data from Citibase.

Figure 4
Ex ante real rate



Note: Shaded areas indicate NBER-dated recessions.
Source: Based on data from Citibase.

1970s were times when governments were expected to do good things for their citizens, and hurting a subset of them for the sake of curing a social problem seemed unfair and wrong.[14] In an address before the joint meeting of the American Economic Association and the American Finance Association, on 29 December 1972, Burns expressed the general sense of the time:

> Let me note, however, that there is no way to turn back the clock and restore the environment of a bygone era. We can no longer cope with inflation by letting recessions run their course; or by accepting a higher average level of unemployment. . . . There are those who believe that the time is at hand to . . . rely entirely on monetary and fiscal restraint to restore a stable price level. This prescription has great intellectual appeal; unfortunately, it is impractical. . . . If monetary and fiscal policies became sufficiently restrictive to deal with the situation by choking off growth in aggregate demand, the cost in terms of rising unemployment, lost output, and shattered confidence would be enormous. (Burns 1978)

So, toward late 1974, policy-makers reversed course and adopted a loose monetary policy, driving interest rates down sharply, to turn the economy around. Note from Figures 4 and 5 that real interest rates were negative or close to zero. Of course, as the economy entered the deep 1975 recession, inflation came down substantially anyway. But, the turnaround in monetary policy then had the implication that inflation would take off again as soon as the economy entered the expansion.[15] Only later, in 1978 and 1979, did the Fed turn "tough" and consciously adopt a tight monetary policy until inflation came down (see how much higher the federal funds

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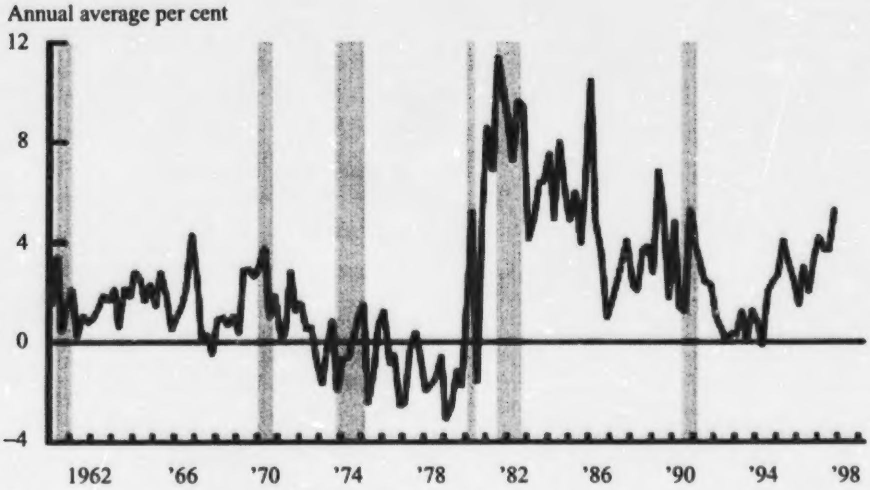
[14] With the experience of the Great Depression and the intellectual foundations provided by Keynes' General Theory, it was generally accepted that governments' responsibility was to preserve the health of the economy. This was put into law in the Employment Act of 1946, which created the CEA:

> There is hereby created in the Executive Office of the President a Council of Economic Advisers . . . to formulate and recommend national economic policy to promote employment, production, and purchasing power under free competitive enterprise.

See De Long (1995) for a discussion of the post-WWII intellectual climate regarding the proper role of government in the economy and the sharp contrast with the pre-WWII climate. As noted earlier, the feasibility of the notion that the government ought to stabilize the economy seemed to be confirmed with the apparent success of stabilization policy in the 1960s.

[15] This was precisely the stop-and-go process that Burns feared, as mentioned in note 9. For another discussion of the stop-and-go nature of inflation in this period, see Barsky and Kilian (2000).

Figure 5
Ex post real rate



Note: Shaded areas indicate NBER-dated recessions.
Source: Based on data from Citibase.

rate went in the early 1980s, and note how it stayed up—with the exception of a brief period of weakness in mid-1980—until after the inflation rate began to fall).

We interpret these observations as being consistent with the view that by the late 1960s and early 1970s, the U.S. economy had fallen into an expectations trap. Through their words and actions, policy-makers sent two clear messages to the population:

- It is technically feasible for policy-makers to stop inflation.
- The costs of doing so were greater than policy-makers could accept.

Under these circumstances, it was perhaps reasonable for people to expect higher inflation. When wage-price controls began to be dismantled in 1973, it would have been reasonable for the public to think that there was now nothing left standing in the way of high inflation. Inflation expectations were even stronger than before. One indication of this is that actual inflation took much longer to begin falling during the 1974 recession than it did in the 1970 recession (see Figure 3). Ironically, while policy-makers expressed frustration with the public for the seeming intransigence of their inflation expectations, the true cause of that intransigence may have been the nature of the monetary policy institutions themselves. This is the implication of the expectations trap hypothesis.

2.2 Phillips curve hypothesis

We now briefly consider the Phillips curve hypothesis about the takeoff in inflation that occurred in the early 1970s. Like the expectations trap hypothesis, this hypothesis is also fundamentally monetarist in that it interprets the rise in inflation as reflecting an increase in money growth. It differs from the expectations trap hypothesis by highlighting a different set of motives on the part of the Fed. Policy-makers believed the CEA estimates that output was below potential in 1971. Under the Phillips curve hypothesis, the Fed responded to this by adopting an aggressively expansionary monetary policy for the same sort of reasons that they appear to have done so in the early 1960s, to restore output and employment.

To see that the economy was below at least one measure of potential in 1971, consider the results in Figures 6 and 7. Figure 6 displays quarterly data on (log) real GDP in the United States for the period 1966Q1 to 1973Q4. In addition, we report two estimates of potential GDP based on the Hodrick and Prescott (1997) filter.[16] One is computed using data covering the period, 1948Q1–1998Q1. A possible problem with this is that by using currently available data we may overstate the estimate of potential GDP available to policy-makers in the early 1970s. They would not have been aware of the slowdown in trend (that is, potential) GDP that started around that time (Orphanides 1999). This motivates our second estimate of potential output, which is based only on data for the period 1948Q1–1973Q4. Note from Figure 6 that the qualitative difference between the two estimates of potential is as expected. However, quantitatively, the difference in levels is quite small. The implied estimates of the output gap appear in Figure 7.[17]

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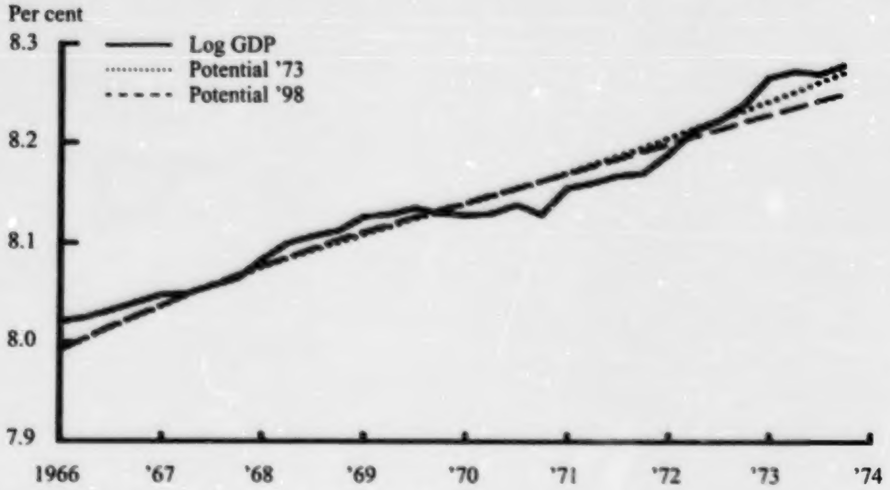
[16] The trend implicit in the H-P filter is a fairly standard way to estimate potential GDP. For example, the Organisation for Economic Co-operation and Development (1999, 205) reports estimates of the output gap computed in this way. Taylor (1999a) also uses this method to compute the output gap. Finally, according to Orphanides and van Norden (1999, 1), "The difference between [actual output and potential output] is commonly referred to as the *business cycle or the output gap* [italics added]." For an analysis of the statistical properties of this way of computing the output gap, see Christiano and Fitzgerald (1999).

There are other output-gap measures based on a different notion of trend. In these, the trend corresponds to the "non-accelerating inflation" level of the variable: the level which, if it occurred, would produce a forecast of zero change in the rate of inflation in the near future. Gap concepts like this are fundamentally multivariate. To see how the H-P filter can be adapted to correspond more closely to this alternative gap concept, see Laxton and Tetlow (1992) and St-Amant and van Norden (1997). We assume that, for our purposes, it does not matter significantly whether the output gap is measured based on the adjusted or unadjusted versions of the H-P filter.

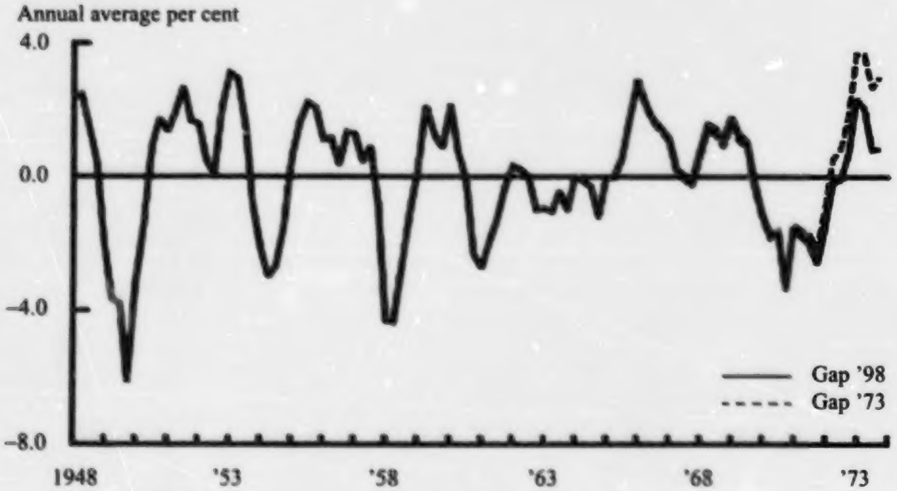
[17] The output gap is measured as 100 x ($\log GDP - \log GDP^{trend}$), where $\log GDP^{trend}$ is the trend in log GDP implied by the H-P filter.

Figure 6
Real GDP and two measures of potential GDP



Source: Based on data from Citibase.

Figure 7
Two measures of GDP gap



Source: Based on data from Citibase.

Note that the two sets of estimates virtually coincide through 1970, and then diverge a little after that. Each estimate implies that the gap in 1971 averaged around 2 per cent.[18]

The 2 per cent gap was substantial by historical standards (Figure 7). Still, the notion that policy-makers actively solicited higher inflation as a way to fight a weak economy conflicts sharply with the words of the chief monetary policy-maker, Burns. Burns was very clear about his distaste for exploiting the Phillips curve for the sake of short-term gains. He certainly accepted the notion that policy could achieve higher output by increasing inflation. After all, his fears about the consequences of fighting inflation with reduced money growth were fundamentally based on a belief in a short-term Phillips curve. His view, which corresponded to the one espoused by Milton Friedman (1968), was that attempts to exploit the Phillips curve for short-term gains would only produce more trouble in the long run.[19] As he put it in testimony before Wright Patman's House Committee on Banking and Currency, 30 July 1974:

> We have also come to recognize that public policies that create excess aggregate demand, and thereby drive up wage rates and prices, will not result in any lasting reduction in unemployment. On the contrary, such policies—if long continued—lead ultimately to galloping inflation, to loss of confidence in the future, and to economic stagnation. (Burns 1978, 170)

It is hard to doubt the sincerity of these words. To Burns, an important lesson of the inflation of the 1970s was that price increases produced by temporary forces could lead to an intractable inflation problem later on. It would have taken an extraordinary amount of duplicity to, on the one hand, complain about the serious economic damage caused by past policy mistakes in not counteracting temporary forces, and on the other hand contribute to them himself.[20]

2.3 Springing the trap

To evaluate our models, we require a simple characterization of what happened when the economy fell into the expectations trap in the early 1970s. For this, consider Figures 8–10, which display the logarithm of real

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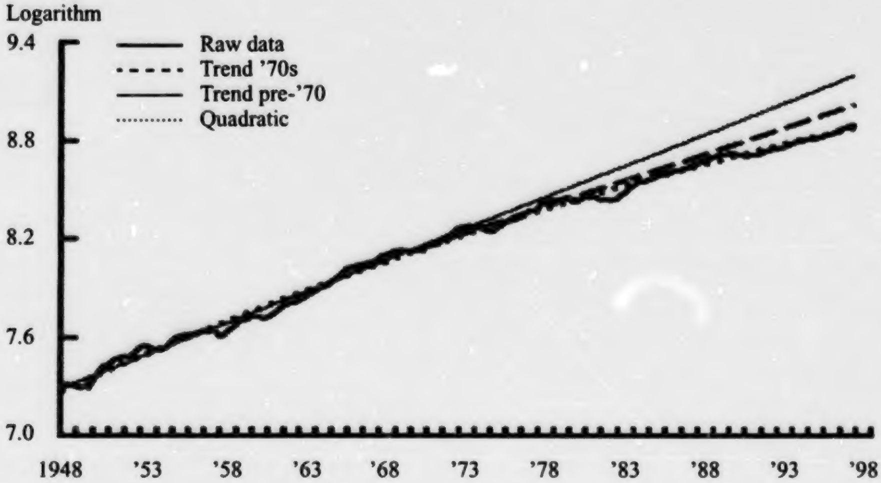
[18] The average gap for 1971 was −1.75 per cent according to the full sample estimate and −1.99 per cent according to the sample that stops in 1973Q4.

[19] See Wells (1994, 72) for a further discussion of Burns' view about the Phillips curve.

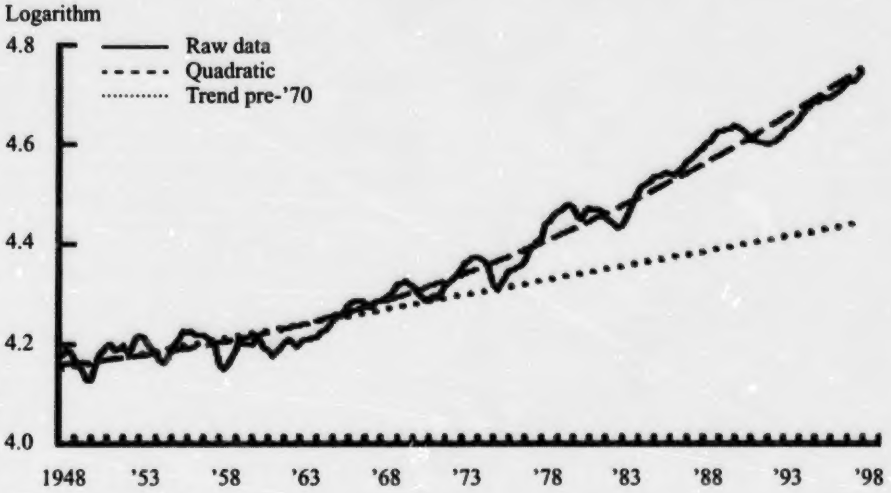
[20] It has been argued that even if Burns was not himself duplicitous, President Nixon was, and Burns acted at the behest of Nixon. To us, the record is inconsistent with this view. See the appendix.

Figure 8
Gross domestic product and trends



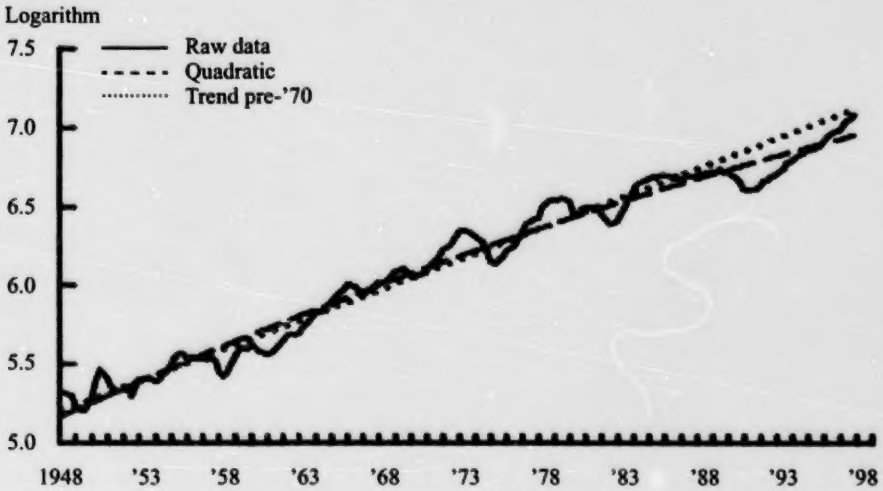
Source: Based on data from Citibase.

Figure 9
Hours of all persons, business sector, and trends



Source: Based on data from Citibase.

Figure 10
Business fixed investment and trends



Source: Based on data from Citibase.

GDP, total hours worked in nonagricultural business, and business fixed investment, respectively. In addition, we display linear trends, computed using the data from the beginning of the sample to 1970Q1, and extrapolated through the end of the sample. These lines draw attention to the trend change that occurred in these variables in the early 1970s. In addition, in each case we also fit a quadratic trend to the entire sample of data.

Consider the GDP data in Figure 8 first. In this case, we have also included a linear trend fit to the data for the 1970s and extrapolated to the end of the sample. What is clear, by comparing the raw data with the two linear trends, is that the growth slowdown that started in the early 1970s became even more severe in the 1980s and the early 1990s. We infer from the fact that the slowdown persisted—even accelerated—in this period, that the inflation and other transient shocks that occurred in the early 1970s must have had little to do with it. Now consider hours worked in Figure 9. Note how they take off beginning in the early 1970s, and how the growth rate seems to just increase continuously throughout the following decades. Again, we infer from the fact that the growth rate continued to rise after the inflation stopped that the inflation and other temporary factors in the early 1970s were not a factor in this development. Finally, note that investment shows very little trend change in the 1970s (see Figure 10). After a pause during the 1974–75 recession, investment returns to its former growth path. Investment does display weakness in the late 1980s and the 1990 recession. But after that, it grows again, returning to the pre-1970s trend line by 1997.

These trend changes in hours worked and output complicate our attempts to assess alternative explanations of the inflation of the 1970s. Ideally, we would like to remove the effect on the data reflecting the factors underlying the persistent change in trend, and study the remainder. We have not found a clean way to do this. The approach we take removes a quadratic trend from each variable and assumes that the result reflects the effects of the inflation and bad supply shocks of the early 1970s. The results are displayed in Figures 11–13. In the 1974–75 recession hours worked fell to around 6 per cent below trend, investment was down 11 per cent, and output was down 3 per cent. At the same time, inflation rose from 4 per cent in 1972 to 10 per cent by the end of the recession. The federal funds rate went from around 4 per cent in 1972 to a peak of around 12 per cent near the end of the recession. The episode is a classic stagflation, with inflation going up and the economy, down.

3 Models

We now report on a quantitative evaluation of the expectations trap hypothesis. For this, we need a mathematical representation of the way the central bank conducts monetary policy and of the way the private economy is put together. We describe two models of the private economy: the limited participation model of Christiano and Gust (1999) and the sticky-price, IS-LM model of Clarida et al.[21]

3.1 Monetary policy rules

There is widespread agreement that the right way to model the Fed's monetary policy is along the lines proposed by Taylor (1993, 1999b). He posits that the Fed pursues an interest rate target, which varies with the state of the economy. A version of this policy rule was estimated using data from the 1970s by Clarida et al. They estimated that the Fed's monetary policy causes the actual federal funds rate, R_t, to evolve as follows:

$$R_t = \rho R_t + (1-\rho) R_t^* . \tag{1}$$

In words, R_t is a weighted average of the current target value, R_t^*, and of its value in the previous period. By setting $\rho = 0$, the Fed would achieve its target, $R_t = R_t^*$ in each period. It might instead prefer $0 < \rho < 1$ if R_t^* exhibits more volatility than it wishes to see in the actual funds rate. The target interest rate is determined according to the following expression:

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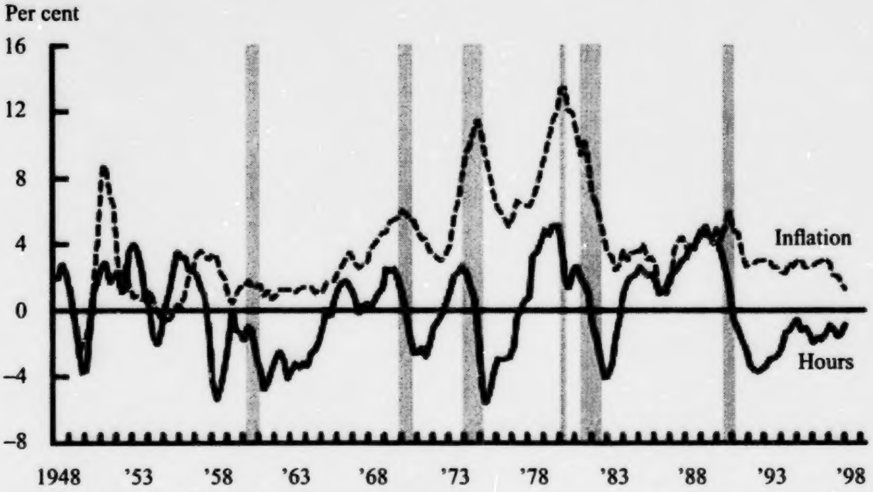
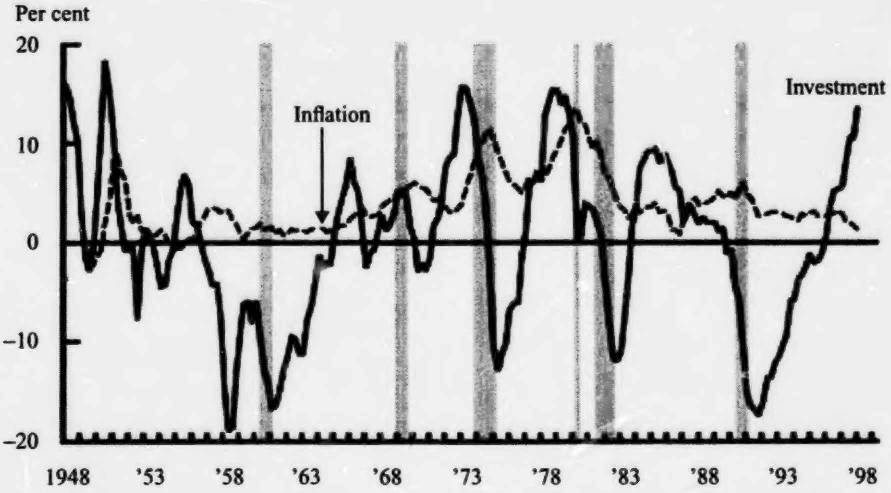
[21] The limited-participation model that we use is a modified version of the model in Christiano, Eichenbaum, and Evans (1998).

Figure 11
Detrended hours and inflation



Note: Shaded areas indicate NBER-dated recessions.
Source: Based on data from Citibase.

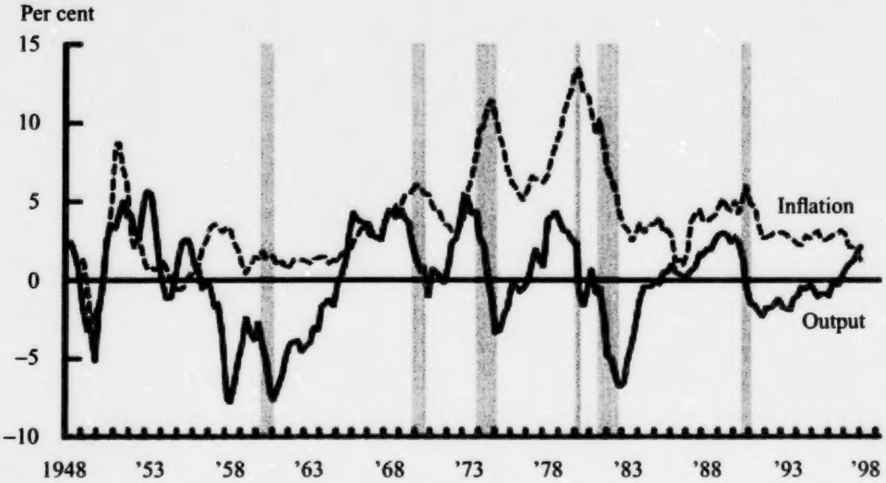
Figure 12
Detrended investment and inflation



Note: Shaded areas indicate NBER-dated recessions.
Source: Based on data from Citibase.

Figure 13

Detrended output and inflation



Note: Shaded areas indicate NBER-dated recessions.
Source: Based on data from Citibase.

$$R_t^* = \text{constant} + \alpha E_t \log(\pi_{t+1}) + \gamma y_t, \pi_{t+1} = \frac{P_{t+1}}{P_t}, \qquad (2)$$

where P_t is the price level, E_t is the date t conditional expectation, and y_t is the per cent deviation between actual output and trend output. The estimated values of ρ, α, and γ are 0.75, 0.8, and 0.44, respectively. We use these parameter values in our analysis.[22]

The idea is that a tough central banker who is committed to low inflation would adopt a rule with a large value of α. A central banker that is less able to commit to low inflation would have a low value of α. Clarida et al.'s estimate for the 1970s is relatively low. The value they estimate using data after 1979 is higher, and this is a period when monetary policy is thought to have been characterized by greater commitment to low inflation. To see how much tougher monetary policy became in 1979, consider Figures 4, 5, and 14. Figures 4 and 5 show that the real rate was noticeably higher in this period. Figure 14 exhibits the difference between what the federal funds rate actually was and what it was predicted to be based on equation (1). Up until 1979, these differences were on average close to zero. After 1979, the average shifts up noticeably (see the horizontal line). This indicates that the actual funds rate in that period was higher than what a policy-maker following the pre-1979 rule would have allowed.

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[22] Clarida et al. (1998) use revised data to estimate the policy rule for the 1970s. Orphanides (1997) argues that constructing y_t using final revised data may give a very different view of y_t than policy-makers in the 1970s actually had. As noted above, he argues that the productivity slowdown that is thought to have occurred beginning in the early 1970s was not recognized by policy-makers until much later in that decade. As a result, according to Orphanides, real-time policy-makers in the 1970s thought that output was further below potential than current estimates suggest. In private communication, Orphanides has informed us that when he uses real-time data on y_t and the other variables to redo the Clarida et al. estimation procedure, he finds that the point estimated for ρ, α, and β for the 1970s change. They move into the region where our models no longer imply that self-fulfilling inflation takeoffs are possible. The standard errors on the point estimates are large, however, and a standard confidence interval does not exclude the Clarida et al. point estimates that we use.

How well does this policy rule capture our observations about monetary policy in the 1970s? In one sense, it misses. We saw that there were times when the Fed was very tough, and other times when it was accommodating. We think of this policy rule as capturing the Fed's behaviour on average. On average, it was accommodating.

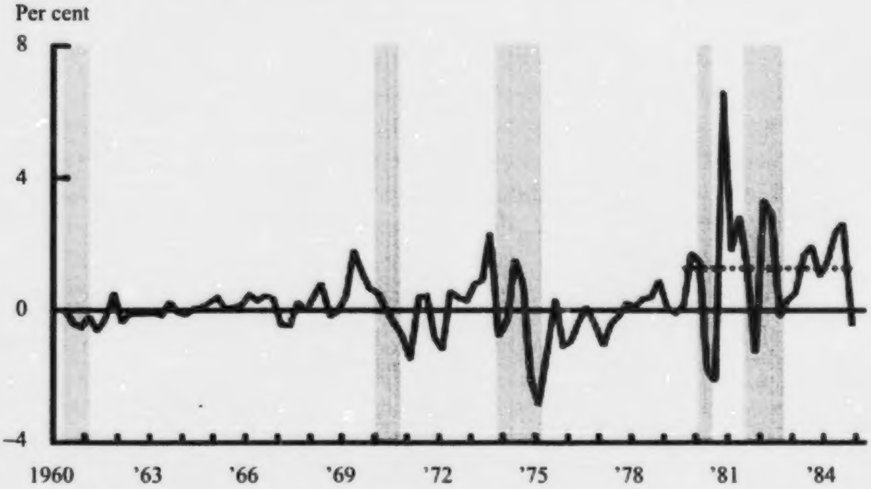
3.2 Two models of the private economy

We now present a brief description of the models used in the analysis. The mathematical equations characterizing both models may be found in Christiano and Gust (1999).

Consider the limited-participation model first. Recall that this model emphasizes a working-capital channel in the firm sector: In order to produce output in a given period, firms must borrow funds from the financial intermediary. By increasing and decreasing its injections of liquidity, the central bank can create an abundance or scarcity of those funds. The resulting interest rate fluctuations then have a direct impact on production. A scarcity of funds in the financial intermediary drives up the interest rate and induces firms to cut back on borrowing. With fewer funds with which to hire factors of production, they cut back on production. Similarly, an abundance of funds leads to a fall in the interest rate and an expansion of output.

The mechanism whereby a rise in expected inflation may lead to a rise in actual inflation in this model was sketched earlier, but we summarize it again here for convenience. When there is an increase in expected inflation (that is, $E_t \log(\pi_{t+1})$ rises) and $\alpha < 1$, this translates into a decrease in the real interest rate, $R_t - E_t \log(\pi_{t+1})$. This leads households to reduce their deposits with the financial intermediary, and has the effect of creating a scarcity of the funds available for lending to firms. Upward pressure develops on the rate of interest. In pursuing its policy of not letting the interest rate rise too much, the monetary authority must inject some liquidity

Figure 14
Actual federal funds rate minus value predicted by 1970s rule



Note: Shaded areas indicate NBER-dated recessions.
Source: Based on data from Citibase.

into the banking system. This injection then produces a rise in prices, thus validating the original rise in inflation expectations. Since the monetary authority does permit some rise in the nominal rate of interest (that is, $\alpha > 0$), this has the effect of depressing output, employment, consumption, and investment. Thus, the limited-participation model predicts that a self-fulfilling inflation outburst is associated with stagflation.

The pure logic of the model permits an inflation outburst to be triggered for no reason at all or in response to some other shock. In our modelling exercise, we treat the jump in expectations as occurring in response to a transitory, bad supply shock. Here, we have in mind the commodity supply shocks, including the oil shock, of the early 1970s.

Now consider the Clarida et al. model. In that model, a fall in the real rate of interest stimulates the interest-sensitive components of demand. The expansion of demand raises output and employment through a standard sticky-price mechanism. In particular, firms are modelled as setting their prices in advance and then accommodating whatever demand materializes at the posted price. As output increases, the utilization of the economy's resources, particularly labour, increases. This produces a rise in costs and these are then gradually (as the sticky-price mechanism allows) passed into higher prices by firms. In this way an increase in the expected inflation rate gives rise to an increase in actual inflation, as long as $\alpha < 1$.

A feature of Clarida et al.'s model is that it does not have investment or money. The absence of investment reflects the assumption that only labour is used to produce output. Money could presumably be incorporated by adding a money-demand equation and then backing out the money stock using output and the interest rate. Clarida et al. do not do this and neither do we.

Evidently, the Clarida et al. model implies that a self-fulfilling outburst of inflation is associated with a rise in employment and output. If there were no other shocks in the model, then it is clear that the Clarida et al. model would have a problem, since it would be inconsistent with the phenomenon of stagflation observed in the 1970s. However, we treat the Clarida et al. model in the same way as the limited-participation model. In particular, we model the jump in inflation expectations as occurring in response to a bad supply shock. So, in principle, it might be compatible with the low output observed in the 1970s because of the bad supply shock.

3.3 Interpreting the Taylor rule in the two models

The various hypotheses about inflation that we discuss in this paper focus on the *motives* of policy-makers. The Taylor rule summarizes their *decisions*, and is silent on what motives produced these decisions. Still, in assessing the limited-participation and Clarida et al. models, it is useful to speculate on what sort of motives might produce a Taylor rule with $\alpha < 1$ in these models.

In the limited-participation model, we interpret $\alpha < 1$ as reflecting the working-capital expectations trap considerations discussed above. That is, in this model a rise in inflation expectations confronts the Fed with a dilemma because it places the goals of low inflation and stable output in direct conflict. An interpretation of $\alpha < 1$ is that this reflects the Fed's relatively greater concern for the output goal, as in the working-capital expectations trap scenario.

By contrast, in the Clarida et al. model a rise in expected inflation does not put the low inflation, stable output goals in conflict. By simply saying *no* to high money growth and inflation, the Fed in the Clarida et al. model prevents output and inflation from simultaneously going above trend. So, $\alpha < 1$ in the Clarida et al. model does not appear to reflect the type of central bank dilemmas that are at the heart of the expectations trap scenarios described above. Perhaps the only interpretation of $\alpha < 1$ in the Clarida et al. model is that it reflects a mistake on the part of policy-makers. Under this interpretation, policy-makers were not aware that with $\alpha < 1$, a self-fulfilling inflation outburst is possible. That is, policy-makers simply did not know that they could have gotten out of the high inflation by raising the rate of interest sharply. Our reading of the policy-making record of this period makes us deeply skeptical of this idea.[23]

4 Evaluating the Models

Neither of our models captures the events at the level of detail described earlier, nor would we want them to. The question is whether we have a model that captures the broad outlines of the takeoff in inflation in the 1970s.

We construct a simulation of the 1970s using the two models described in the previous section. We specify that the fundamental exogenous shock in this period is a shift down in the production function by 1 per cent.[24] That is, for each level of the inputs, output falls by 1 per cent. Inflation expectations in the wake of this shock are not pinned down. They are exogenous variables, like the technology shock.[25] We picked the expectations subject to two constraints. First, we required that the limited-participation model display a long-lasting, substantial response of inflation to the shock. Second, we required that the price level in the period of the production-function shock be the same between the two models.

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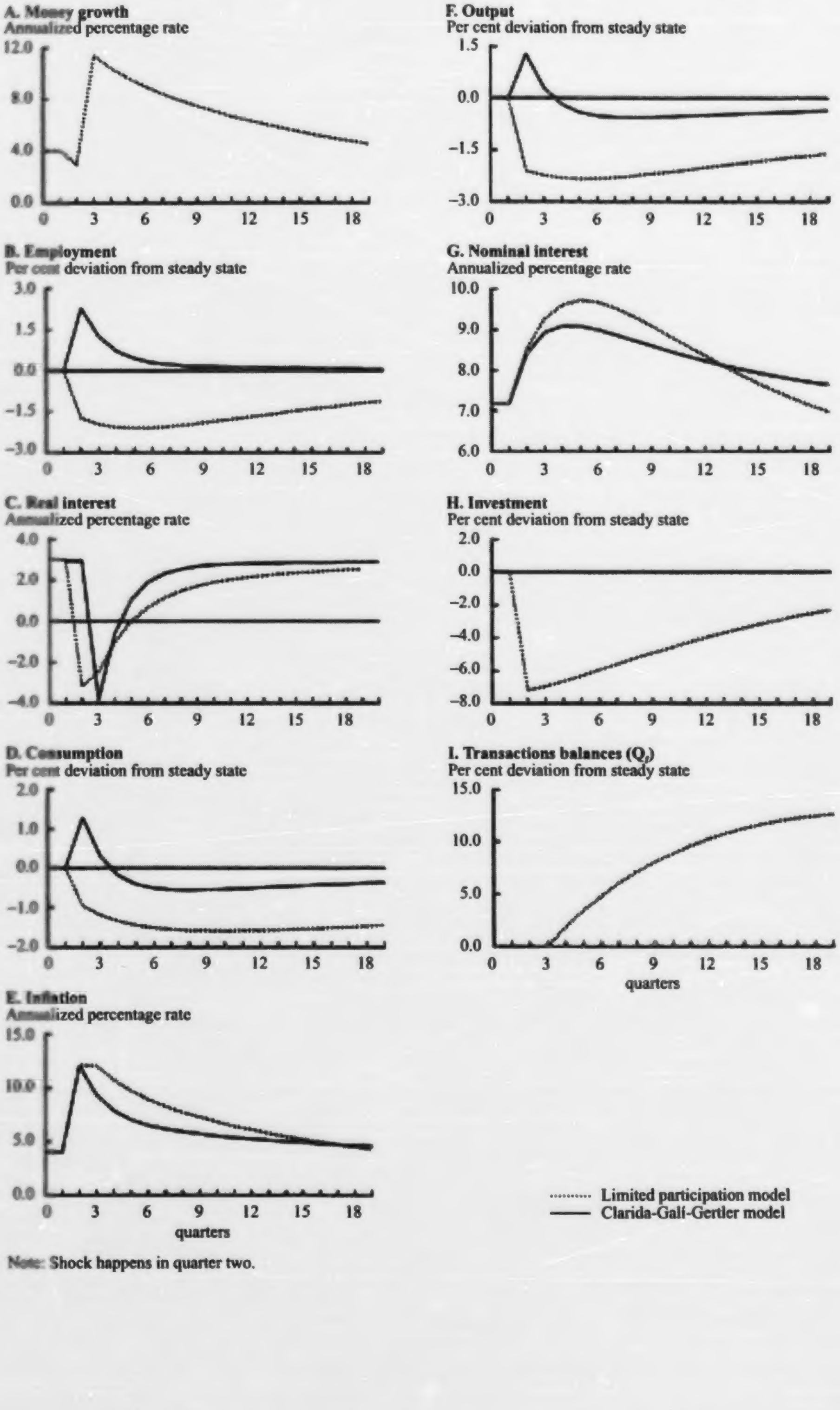
[23] Woodford (1998) develops an alternative interpretation of $\alpha < 1$ by building on the assumption that fiscal policy (something we abstract from in our analysis) was "non-Ricardian" during the 1970s. Using the fiscal theory of the price level, he argues that with fiscal policy satisfying this condition, the Fed was forced to set $\alpha < 1$ to avoid an even more explosive inflation than the one that actually occurred. For a simplified explanation of this argument, see Christiano and Fitzgerald (2000). The fiscal theory of the price level offers another potential explanation of the takeoff in inflation in the 1970s, one that is not based on self-fulfilling expectations and that assigns a central role to fiscal policy rather than monetary policy. While this interpretation is controversial, it deserves serious consideration. See Cochrane (1998) and Woodford (1998) for further discussion.

[24] The production function is $Y_t = \exp(z_t)K_t^{\theta}L_t^{1-\theta}$, where Y_t denotes gross output, K_t denotes the stock of capital, and L_t denotes labour. The state of technology, z_t, evolves according to $z_t = \rho_z z_{t-1} + \varepsilon_{z,t}$, with $\rho_z = 0.95$. In the limited-participation model, $\theta = 0.36$ and in Clarida et al., $\theta = 0$. The simulation involves setting $\varepsilon_{zt} = -0.01$ for $t = 2$ and $\varepsilon_{zt} = 0$ for all other t. With this value of ρ_z the state of technology remains 0.7 per cent below trend after 10 periods and 0.4 per cent below trend after 20 periods.

[25] There is one important difference. Shocks to the production function can occur for any parameter values of the model. Shocks to expectations can only exist for certain parameter values.

Figure 15
Response to technology shock in two different models



Note: Shock happens in quarter two.

Consider the limited-participation model first.[26] Figure 15 exhibits the response of the variables in that model to a bad technology shock. The shock occurs in period 2. Not surprisingly, in view of our earlier discussion, the shock drives output and employment down and inflation up. The monetary authority reacts immediately to the increase in inflation expectations by reducing the money supply to push up the rate of interest (recall, the coefficient on expected inflation in the Taylor rule is positive).

Notice the variable, Q, in the model. That is the part of households' financial wealth that they hold in the form of transactions balances. When inflation expectations go up and $\alpha < 1$, then households increase Q and correspondingly reduce the part of their financial wealth that they deposit with financial intermediaries. The increased value of Q in period 3 reflects households' higher inflation expectations. They understand that the monetary authority's policy rule implies that the nominal rate of interest will go up, but that it will go up by less than the increase in inflation expectations (that is, $0 < \alpha < 1$). That is, they expect the real rate to go down. This leads them to increase the funds allocated to the goods market by raising Q_3, that is, to drain funds from the financial intermediary. To guarantee that the rate of interest only rises by a small amount (α is small), the monetary authority must inject funds into the financial intermediary to make up for the loss of funds due to the rise in Q_3. The rise in the interest rate that occurs with all this produces a fall in output and employment. The stagflation persists for a long time. Money growth, inflation, and the nominal interest rate remain high for years. Output, employment, consumption, and investment are down for years. Investment is low, despite the low real rate of interest, because inflation acts like a tax on investment in this model.[27] Note that the effects are quite large. Output and employment remain 2 per cent below trend for a long time, and money growth, inflation, and interest rates are more than 6 percentage points above their steady state. The fall in investment is over 6 per cent. Inflation rises from 4 per cent to about 10 per cent and the interest rate rises from about 7.2 per cent to 10 per cent. These results are tentative, however, since the size of the supply shock, 1 per cent, was not based on a careful analysis of the data. Nor was the response of inflation expectations chosen carefully. Still, the results build confidence that the working-capital expectations trap hypothesis can deliver quantitatively large effects.

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[26] For details of model parameterization, see Christiano and Gust (1999). The version of the limited-participation model underlying the calculations in Figure 15 is the one in which investment is a cash good, what Christiano and Gust (1999) call the "benchmark" model. They also consider the version of the model in which investment is a credit good. The simulation of the 1970s using the Clarida et al. estimated Taylor rule resembles the results in Figure 15.

[27] Feldstein (1997) has argued that high inflation hurts investment, though he emphasizes a mechanism that operates through the explicit tax system.

What is the reason for these persistent and large effects following a technology shock? Fundamentally, it is bad monetary policy. With a less-accommodating monetary policy, it would not be an equilibrium for inflation expectations to jump so much, and so the nominal interest rate would not rise so much. With a smaller interest rate rise, the negative output and employment response to a bad technology shock would be reduced. Figure 16 exhibits what happens in our benchmark limited-participation model when the policy rule estimated by Clarida et al. to have been followed in the post-Volcker period is used.[28] In this case, the equilibrium is (locally) unique.[29] Note that the fall in output and employment is smaller here. The rise in the interest rate is smaller too.

We think of a small value of α in the pre-Volcker policy rule as reflecting that the rule is the decision of a policy-maker without an ability to commit to low inflation. If we interpret the inability to commit as reflecting that the policy-maker has too soft a heart for economic agents, then there is plenty of irony here. The soft-hearted policy-maker in the end does greater damage to the economy than a hard-hearted one who can commit to low inflation.[30]

Now consider the Clarida et al. model. Figure 15 exhibits the dynamic response of the variables in that model to a 1 per cent drop in technology. Note from the figure that in the Clarida et al. model, employment and output rise in response to the shock. After four quarters, output is down, but the employment response remains up for several years. This dynamic response pattern reflects two things. First, in sticky-price models the direct effect on output of a bad technology shock is at most very small, since output is demand determined. As a result, a bad technology shock actually has a positive effect on employment in these models

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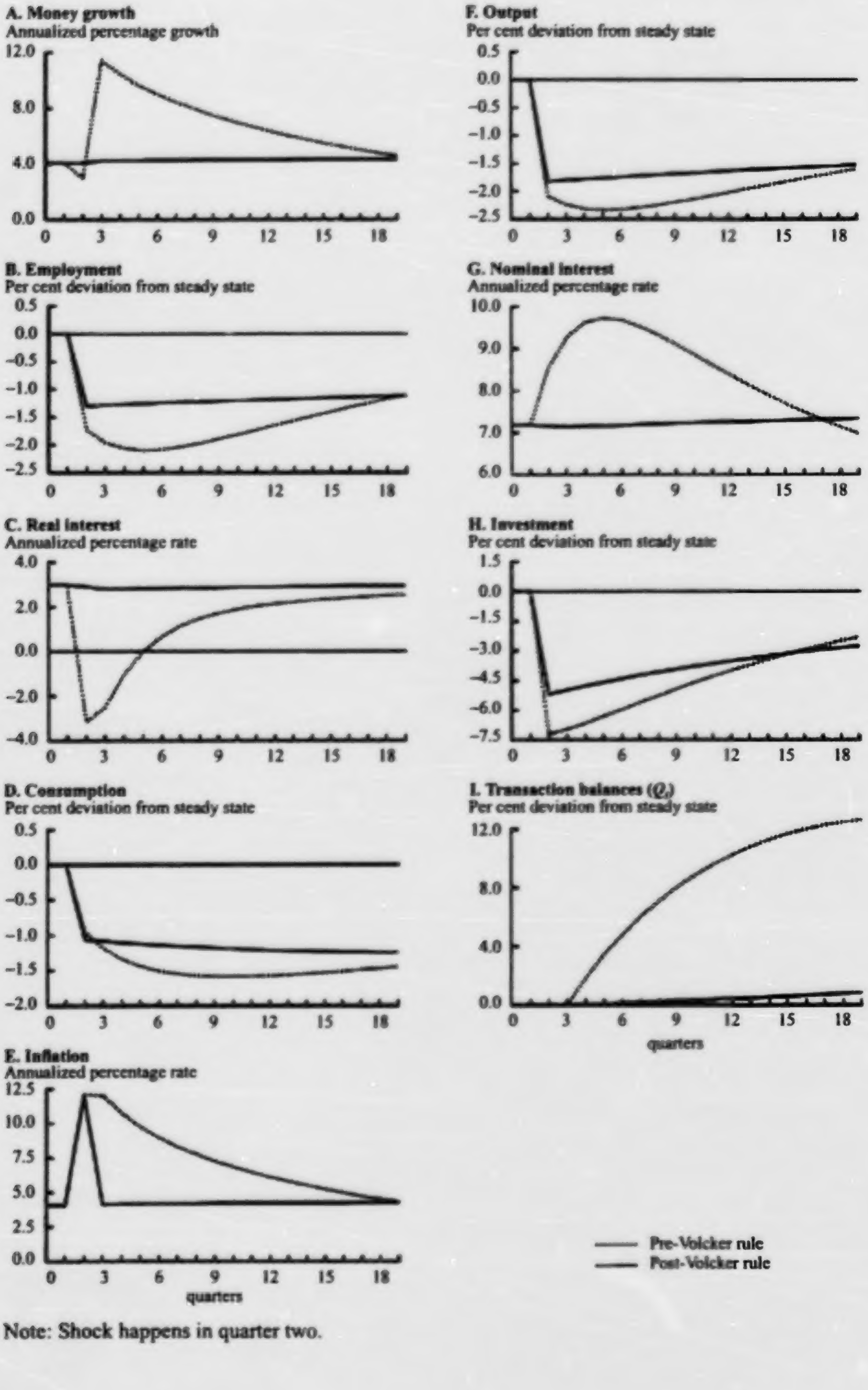
[28] This uses a larger value of α.

[29] The result that raising α above unity eliminates expectations traps (at least, locally) is somewhat model specific. In some models this does not work and the central bank would have to adopt a different policy to rule out expectations traps.

[30] It deserves repetition that the policy rules have not been derived from well-specified optimization problems of policy-makers and that our discussion represents an informal interpretation. For an explicit analysis based on policy-maker optimization, see Chari, Christiano, and Eichenbaum (1998).

Figure 16
Response to a negative technology shock under two different Taylor rules



Note: Shock happens in quarter two.

(see Galí 1999, and Basu and Fernald 1999).[31] Second, a self-fulfilling rise in inflation by itself produces a rise in output and employment in the Clarida et al. model, as the fall in the real rate of interest stimulates the interest sensitive components of aggregate demand.

The simulation results in effect present the combined effects of both a self-fulfilling rise in inflation and a bad technology shock. In view of the observations in the previous paragraph, it is not surprising that the response of employment is positive. Output is also high for several quarters, although it eventually goes negative as the effect of the bad technology shock swamps the effect of the increase in employment. The employment response in particular puts this model in sharp conflict with the observed stagflation of the 1970s.

We conclude that the limited-participation model provides a reasonable interpretation of the takeoff in inflation in the 1970s as a working-capital expectations trap. The effects in the model are large, and qualitatively of the right type: The model predicts a stagflation. The alternative model that we examine, the one proposed in Clarida et al., provides a less-convincing explanation of the 1970s. The model predicts a boom. In addition, as discussed in the previous section, the model's explanation of why policy-makers allowed the inflation rate to take off is not very compelling.

Conclusion

We have argued that the expectations trap hypothesis helps explain the high inflation in the early 1970s, particularly the takeoff that began in 1973. We have argued against another hypothesis, the Phillips curve hypothesis. According to that, the high inflation was an unfortunate but necessary risk that the Fed was willing to take when it decided to jump-start a weakened economy in the early 1970s. These hypotheses are in fact quite similar, and so it may appear that we are splitting hairs in trying to differentiate between them. Is there anything at stake in the distinction?

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[31] The reasoning is simple. Let D denote demand and P and Y denote price and output. Then, $PY = D$. In a sticky price model, P cannot change so that if D does not change then Y cannot change either, even if there is a shock to technology. Of course, if the shock is such that it takes more people to produce a given level of output, then a fall in technology results in a rise in employment. This response of employment to a bad technology shock is not robust to all specifications of monetary policy. For example, if α is sufficiently large in the Clarida et al. model, then the rise in anticipated inflation produced by a bad technology shock leads the monetary authority to raise the interest rate a lot, driving down D. If the fall in D is sufficiently large, then a bad technology shock could actually lead to a fall in employment. Our results indicate that under the estimated monetary policy rule, employment rises after a bad technology shock in the Clarida et al. model.

We believe there is. Under the Phillips curve hypothesis, preventing a repeat of the high inflation of the 1970s is a relatively easy task: *just say no* to high money growth as a way to stimulate the economy. Under the expectations trap hypothesis, the problem of inflation is not solved so easily.

According to the expectations trap hypothesis, high inflation is the Fed's reaction to pressures originating in the private economy. The entire policy-making establishment, when confronted with these pressures, may truly not *want* to say no. To see this, imagine that bad supply shocks drove prices and unemployment up, and people responded by signing inflationary wage and price contracts. Certainly, the Fed would not be happy about following the path of accommodation and validating the expectations incorporated in the wage and price contracts. But, it may well choose to do so anyway. With the White House, the Congress, and the public at large bearing down on it like a great tsunami, the Fed may simply feel it has no choice.

So, the expectations trap hypothesis implies that it is not so easy to prevent a resurgence of a 1970s style inflation. According to that hypothesis, fundamental institutional change is needed to guarantee that people would never reasonably expect a takeoff in inflation in the first place. What sort of institutional change might that be?

We have not attempted to answer this question. There is a large range of possibilities. One is that the necessary changes have *already* occurred. According to that, the simple memory of what happened in the inflation of the 1970s is enough to stay the hand of a policy-maker tempted to validate the expectations incorporated in inflationary wage and price contracts. This is of course an attractive possibility, but there is reason to doubt it. When the expectations trap argument is worked out formally, it is assumed that the policy-maker has unlimited memory, a clear understanding of the consequences of alternative actions, and excellent foresight (see Chari, Christiano, and Eichenbaum 1998). The logic of expectations traps simply has nothing to do with ignorance. So, the notion that expectations traps became less likely when our eyes were opened by the experience of the 1970s does not seem compelling.

Another possibility is that changes in legislation are needed, changes that focus the legal mandate of the Fed exclusively on inflation. This would make it harder for a Congress and White House, panicked by high unemployment and inflation, to pressure the Fed into tossing inflation objectives to the wind in favour of unemployment. Understanding this in advance, the public would be unlikely to raise inflation expectations in response to transient events, as it seems to have done in the early 1970s.

The expectations trap hypothesis does not say *what* change is needed to prevent a self-fulfilling takeoff in inflation expectations. What it does say is that *if* the government finds a way to credibly commit to not validating high inflation expectations, then costly jumps in inflation expectations will not occur in the first place.

Appendix
Burns and Nixon

It has been argued that, as chairman of the Federal Reserve, Arthur Burns simply did what President Nixon told him to do. Burns initially joined the Nixon administration as a special advisor to President Nixon when the latter took office in 1968. The idea is that the boss-employee nature of that relationship continued when Nixon appointed Burns to be chairman of the Federal Reserve. This impression was reinforced by Stanford Rose in a famous article in *Fortune* magazine in 1974, which suggested that Nixon was able to interrupt the policy-making committee of the Fed with a 1-hour telephone call and control the outcome of the meeting.

Nixon apparently did have *hopes* of influencing Burns when he appointed Burns chairman of the Federal Reserve. In his fascinating biography of Burns, Wells (1994, 42) quotes Nixon as having said to Burns: "You see to it: No recession."

But, according to Wells (1994), the impression that Burns operated at the behest of Nixon is in fact completely untrue. Burns was a man with legendary self-confidence and a powerful, imposing personality. He had been an influential chairman of the CEA under Eisenhower and left a stamp on that institution that is felt even today. During that time, according to Wells (1994, 29), Burns' relationship to Nixon was that of a

> senior partner: He was older than Nixon and enjoyed more influence with Eisenhower and his lieutenants than did the vice president. Burns thought of Nixon as a protege and treated him with what one friend described as "slight condescension." . . . After Nixon became president, Burns had trouble adjusting to a subordinate position. . . . He lectured Nixon on whatever issue was at hand, usually at great length and in considerable detail. Burns would also bluntly contradict the president or anyone else in the administration with whom he disagreed. . . .

The diaries of H.R. Haldeman (1994), Nixon's chief of staff, confirm this impression of a self-assured Burns who expected to get his way. For example, here are a couple of entries about Burns while he was in the Nixon White House: "Huge Burns flap because he didn't get in to see [the President]. . ."; (p. 54) "Big flap with Arthur Burns on AID. . . ." (p. 59)

Wage and price controls were a major source of friction between Burns and Nixon: Burns concluded that they were necessary, and Nixon was opposed. For example, according to Haldeman (1994, 310) Nixon told his cabinet on 29 June 1971, "Our decisions are that there will be no wage-price controls, no wage-price board." According to Wells (1994, 70–7), the disagreement provoked "ugly" confrontations between Burns and the White House, as Burns went public with his views. In the end, in mid-August, Nixon decided to impose wage-price controls after all. The episode shows that, as Wells (1994, 100) puts it, "The chairman was clearly no pliant tool of the chief executive but rather did whatever he thought was best."

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Discussion

Tiff Macklem

Limited-participation (LP) models are coming of age. Having passed the test of empirical relevance at one level, LP models have matured to the point that they are now being used to examine questions that are of direct interest to monetary policy-makers. A number of recent contributions illustrate this development. Chari, Christiano, and Eichenbaum (1998) study optimal monetary policy in an LP model, Christiano and Gust (1999) examine the performance of alternative simple interest rate reaction functions in an LP model, and this latest contribution from Christiano and Gust (2000) considers the ability of an LP model to explain the pre-eminent monetary policy blunder of the post-war era—the great inflation of the 1970s.

The entry of LP models into the policy arena is a welcome development. The workhorse model of monetary policy—the sticky-price model—has been remarkably resilient, adapting to rational expectations and, to a lesser extent, optimizing agents; however, wage and price stickiness has carried a heavy load in the sense that without it, most models cannot explain the observed short-run consequences of monetary actions for real variables. While few policy-makers believe wages and prices are perfectly flexible, it is probably also fair to say that many believe this is not the only relevant rigidity. Moreover, everyone can agree that there is considerable uncertainty about how the monetary transmission mechanism works, so we should not put all our eggs in one basket. The LP model is an interesting alternative. It embodies a radically different view of the transmission mechanism—one based on rigidities in portfolio decisions between liquid and illiquid assets—and is capable of reproducing the salient stylized facts regarding the real and nominal effects of a monetary injection both qualitatively and quantitatively, provided we assume sufficient portfolio-adjustment costs.

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* I am grateful to Hope Pioro for valuable technical assistance.

In this the latest contribution to the LP research program, Christiano and Gust argue that not only is the LP model a credible alternative to the sticky-price (SP) model, it can actually do a better job of explaining the defining episode in post-war monetary history—the great inflation of the 1970s. This leads naturally to the conclusion that to avoid a recurrence of 1970s-style inflation, we need to take seriously the implications of LP models for the design of monetary institutions and monetary rules.

The Christiano and Gust story runs like this. They begin with the premise that the stagflation of the 1970s was caused by the combination of a negative technology shock (that was observed by policy-makers) together with an inappropriate monetary reaction function. The monetary rule they use is not any arbitrary reaction function, but one estimated on data for the 1970s by Clarida, Galí, and Gertler (1999). The key feature of this nominal interest rate rule is that the coefficient on expected inflation is less than 1, so that self-fulfilling outbursts of inflation are possible. Christiano and Gust demonstrate that when this rule is used in LP and SP models, a negative technology shock produces a sharp rise in inflation and a fall in real interest rates in both models. Thus, with respect to inflation and real interest rates, the LP and SP models do equally well in explaining the 1970s. What distinguishes the LP model is its ability to generate stagflation. In the SP model the decline in real interest rates stimulates spending and thus output, so rising inflation is associated with higher (not lower) output. In contrast the LP model generates a period of high inflation and low output—stagflation—as observed in the 1970s.

Christiano and Gust's paper is fascinating. The basic premise that the great inflation of the 1970s is the joint outcome of a negative technology shock and a destabilizing monetary rule is both interesting and provocative, and the idea of evaluating alternative models on the basis of their properties when the usual root conditions are not satisfied is intriguing. I do have one specific comment that I want to explore in some detail.

Christiano and Gust's interpretation of the 1970s is controversial. An alternative explanation of the 1970s is that the excessive monetary (and fiscal) easing was the result of policy-makers' failure to identify both the slowdown in productivity growth that occurred in the first half of the 1970s and the roughly coincident rise in the non-accelerating-inflation rate of unemployment. Although inflation was clearly rising in the first half of the 1970s, rising unemployment and weak output growth were interpreted as evidence of mounting excess supply. This, it was thought, would bring inflation down, so what was needed was not restrictive policies to control inflation, but stimulative ones to close the growing excess-supply gap. The result of this colossal misreading of the state of the economy was sharply higher inflation and a shift from government budget surpluses to budget deficits.

This alternative to Christiano and Gust's interpretation of the 1970s is not a new story, but a recent paper by Orphanides (1999) has given it new weight. Orphanides compiles real-time estimates of the output gap as published by the Council of Economic Advisers and the Board of Governors of the Federal Reserve System from the late 1960s to the 1990s. As Figure 1 (reproduced from Orphanides) reveals, the differences between the real and the final estimates of the output gap in the 1970s are both huge and incredibly persistent. The difference between the real-time and final estimates of the output gap reaches almost 10 percentage points in 1976, and even by the end of the decade the degree of excess supply is overestimated (relative to the final estimate) by about 3 percentage points for most of the 1970s. Orphanides goes on to show that when a standard Taylor rule using real-time estimates of the output gap is simulated together with simple estimated backward-looking IS and Phillips curves, the resulting inflation profile closely matches the experience in the 1970s. The standard Taylor rule (in deviation form $i_t = \alpha\pi_t + \gamma y_t$) has a coefficient on inflation (α) of 1.5, which is clearly greater than 1. Thus Orphanides' interpretation of the 1970s is very different from Christiano and Gust's. The problem was not one of a destabilizing monetary rule, but one of mismeasuring the output gap.

In my view, Orphanides' story is more believable. The Christiano and Gust story requires the monetary policy-makers to have virtual superpowers in identifying an unobserved technology shock, while at the same time possessing a complete lack of understanding of the stability conditions of simple dynamic macro models. Perhaps I am too close to the issue, but I find both these requirements difficult to swallow.

The compelling nature of Orphanides' story leads to an obvious question: How well can LP and SP models explain the 1970s, starting from the premise that the monetary rule was stable, but the level of potential output was overestimated? Since the SP model has only three equations, this is the obvious place to start in answering this question.

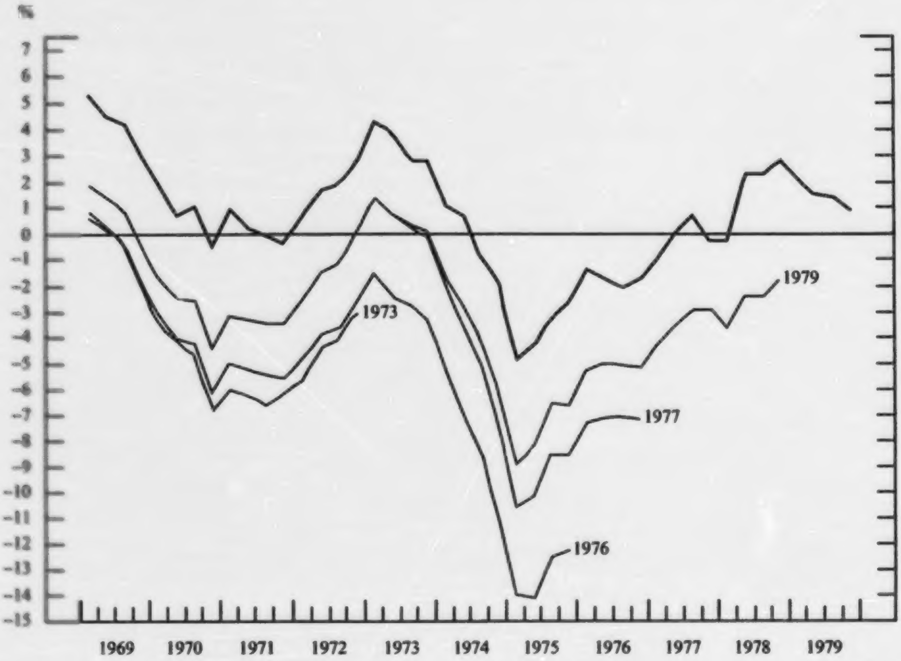
The three equations are an IS curve,

$$y_t = E_t y_{t+1} - \frac{1}{\sigma}(i_t - E_t\pi_{t+1});$$

a Phillips curve,

$$\pi_t = \beta E_{t+1}\pi_{t+1} + \kappa y_t - \kappa z_t;$$

Figure 1
The 1970s output-gap measurements



Notes: The dark line indicates the final historical series for the output gap with data available at the end of 1994. Each thin solid line shows the historical series for the output gap based on data available in the first quarter of the year shown.
Source: Orphanides (1999, figure 11).

and a monetary rule. Christiano and Gust use a forward-looking Taylor rule estimated by Clarida, Galí, and Gertler, but for simplicity I replace it with a standard Taylor rule, but with output-gap mismeasurement.

The output gap (y) is actual output $(\tilde{y})$ less potential output. Let potential output be the sum of a constant (which I normalize to zero) and a mean zero technology shock (z). Then actual output is

$$\tilde{y}_t = y_t + z_t.$$

If the technology shock z is readily observable, the monetary authority has no problem measuring the output gap, and the Taylor rule is simply

$$i_t = \alpha\pi_t + \gamma y_t.$$

However, if z is unobservable, the monetary authority must form an estimate of the output gap. For simplicity I assume that the monetary authority does not learn about z over the horizon that is relevant for the real effects of monetary disturbances, an assumption that does not appear to be grossly at odds with experience (see Figure 1). The monetary authority therefore measures the gap by simply observing output (since unconditionally $E(y) = E(\tilde{y} - z) = \tilde{y}$). The resulting Taylor rule is therefore

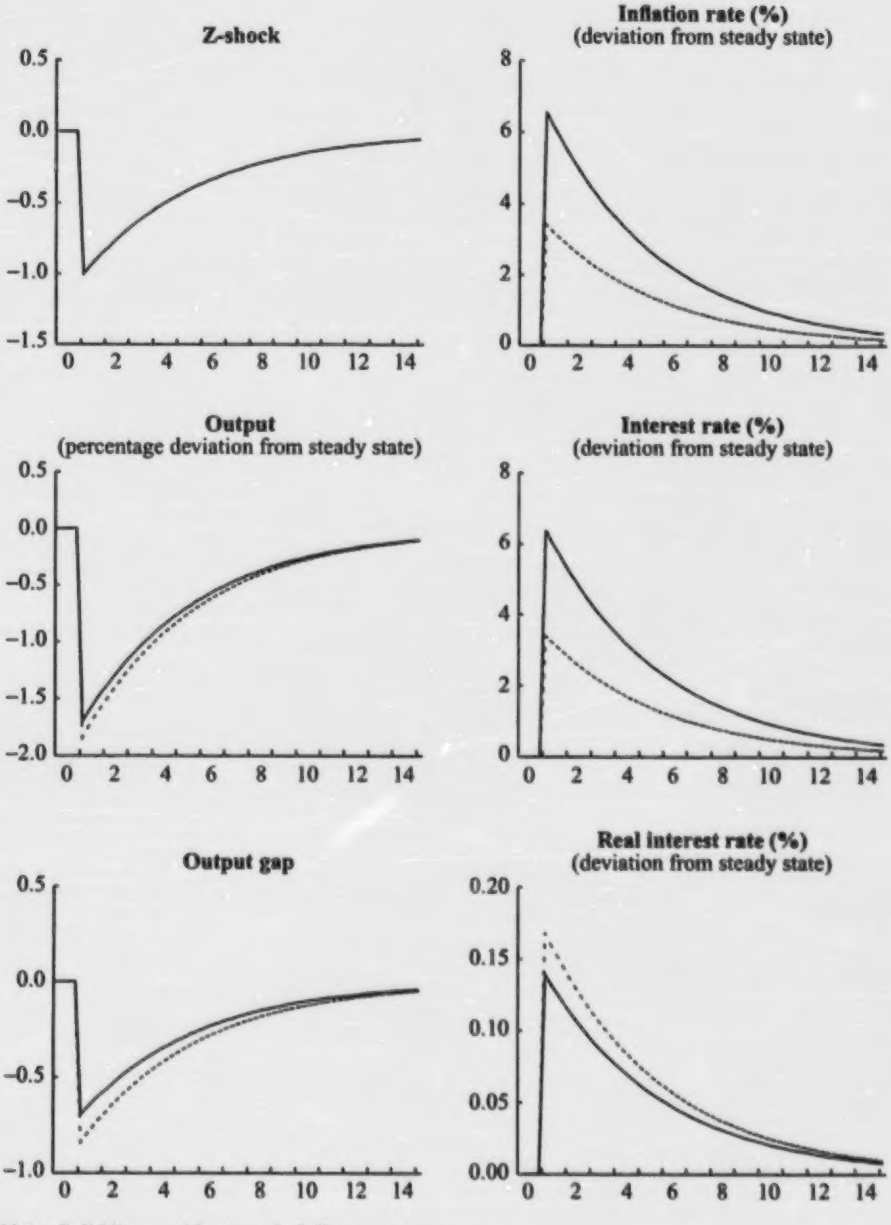
$$i_t = \alpha\pi_t + \gamma\tilde{y} = \alpha\pi_t + \gamma(y_t + z_t).$$

Figure 2 shows the dynamic response of this SP model to the same negative technology shock Christiano and Gust consider. The parameters σ, β, and κ are set as they have them, and α and γ are set to the standard Taylor values of 1.5 and 0.5. The dashed lines in the figure are the dynamic response in the standard SP model with no mismeasurement, and the solid lines are with mismeasurement. The consequences of mismeasurement are significant. In particular, inflation jumps about twice as much in the simulations with mismeasurement. Real interest rates also rise less and output falls less with mismeasurement, but the consequences of mismeasurement for these variables are small relative to those for inflation. Comparing the responses in Figure 2 to the experience of the 1970s, we see that the model with mismeasurement captures the sharp rise in inflation and the fall in output, but does not replicate the observed decline in real interest rates.

Figure 3 shows the dynamic responses to the same shock with a modified Taylor rule that shifts more weight onto the output gap, with the effect of making output-gap mismeasurement more of a problem (specifically $\alpha = 1.1$ and $\gamma = 1.0$). Without mismeasurement the real interest rate rises (as in Figure 2); however, with mismeasurement the real interest rate falls. This produces a very dramatic rise in inflation of over 25 percentage points. The stimulative effects of the negative real interest rates produce a small positive output gap that offsets some of the impact of the negative technology shock on output, but not all of the impact, so output falls, getting us closer to the 1970s in the sense that inflation rises very sharply, and real interest rates and output both fall. However, as in Christiano and Gust's analysis, the output gap goes positive in response to negative real interest rates, and the reason is exactly the same as in Christiano and Gust's analysis. In the SP model, declining real interest rates stimulate spending that, in this demand-driven model, produces excess demand for goods.

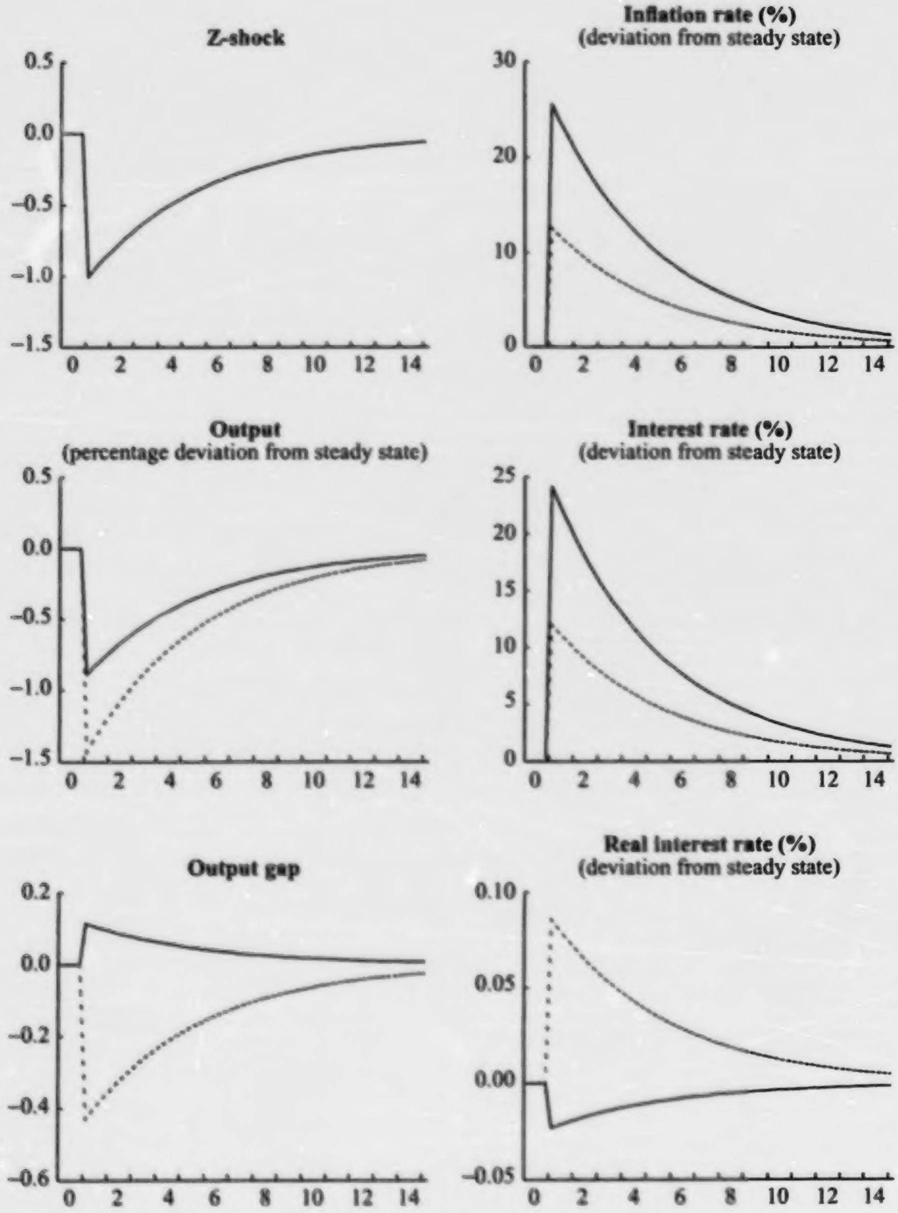
What can we learn from this exercise? Two things, I think. First, whether the 1970s are interpreted as the by-product of an observed negative technology shock and a destabilizing monetary or an *un*observed negative technology shock with a stable rule, the SP model Christiano and Gust

Figure 2
Response to observed and unobserved negative technology shocks with a standard Taylor rule



Note: Solid lines, with error; dash lines, no error.

Figure 3
Response to observed and unobserved negative technology shocks with a modified Taylor rule



Z-shock

Inflation rate (%)
(deviation from steady state)

Output
(percentage deviation from steady state)

Interest rate (%)
(deviation from steady state)

Output gap

Real interest rate (%)
(deviation from steady state)

Note: Solid lines, with error; dash lines, no error.

consider has difficulty in simultaneously generating sharply higher inflation, negative real interest rates, and a negative output gap. The reason is much the same in both cases. This simple SP model has a very rudimentary supply side, and what supply side it does have is weakened by sticky prices. It may well be that an SP model with a richer supply side could do a better job of explaining the 1970s, but as long as sticky prices are active, demand will tend to play a leading role in the short run.

I leave it to the experts to explore whether the LP model continues to explain the 1970s under the mismeasurement story, and I encourage them to do so. If Christiano and Gust find that the LP model does better than the SP model under both interpretations of the 1970s, this would substantially strengthen their conclusion that the lessons from LP models deserve serious attention.

Second, the obvious message from the SP model with mismeasurement is that policy-makers should not put too much weight on the output gap if they are not very confident in its measurement.[1] Figure 4 demonstrates this point in a particularly forceful, if somewhat exaggerated, fashion. It compares the dynamic responses using a standard Taylor rule (i.e., $\alpha = 1.5$ and $\gamma = 0.5$) and an inflation-only rule (i.e., $\alpha = 1.5$ and $\gamma = 0.0$), both with mismeasurement. The inflation-only rule (solid lines) does result in slightly higher real interest rates and thus marginally weaker output. But these differences are second order when compared to the improvement realized on the inflation front. With the inflation-only rule, inflation rises by only about 1/2 of a percentage point as compared to a rise of about 7 percentage points using the standard Taylor rule. The reason for this sharply different outcome is that the inflation-only rule is immune to mismeasurement of the output gap.

Interestingly, the message from this SP model with output-gap uncertainty is very similar to a key result in LP models. In a paper that is closely related to their conference paper, Christiano and Gust (1999) study the performance of Taylor rules in LP models. They find that equilibria in which expectations of inflation are self-fulfilling are eliminated when the Taylor rule responds *aggressively* to inflation and *very little* to output (e.g., they find $\gamma = 1.0$ results in indeterminant solutions).

Perhaps the message for monetary policy-makers from both LP models and SP models is that if they are to avoid the recurrence of 1970s-style inflation, they should limit their ambitions with respect to output stabilization and keep the focus on inflation. The robustness of this conclusion across radically different models is both striking and reassuring.

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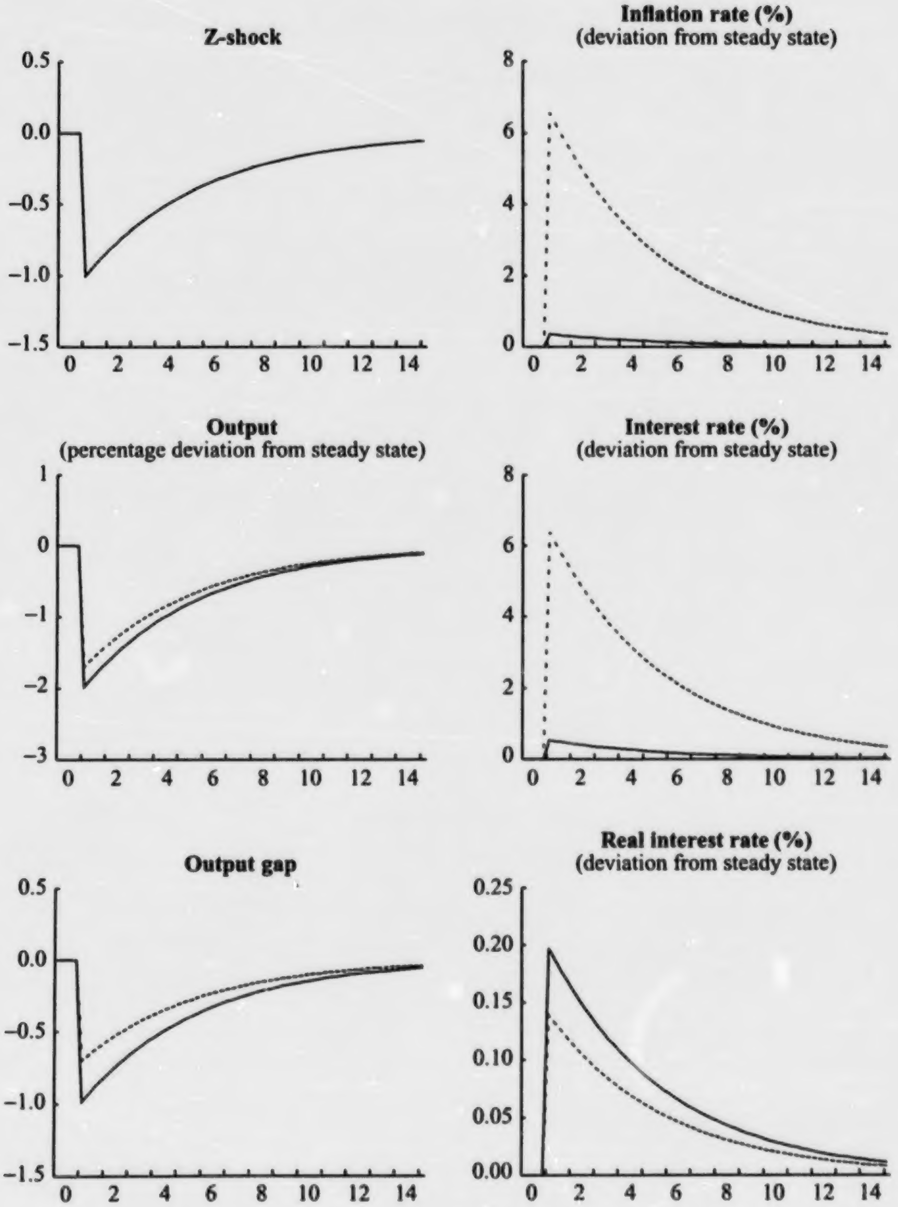
[1] This idea is by no means original (see, for example, Smets 1998).

Figure 4
Response to unobserved negative technology shocks with inflation-only and standard Taylor rules



Note: Solid lines, inflation only; dash lines, standard Taylor.

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Discussion

David Andolfatto

Christiano and Gust's paper is concerned with explaining the behaviour of base-money growth in the United States during the 1970s. They take as given that the Fed was responsible for the great inflation witnessed in that decade and that Fed policy-makers were very averse to the prospect of high inflation. Why, then, did the Fed do it?

Their hypothesis is that the Fed was reluctantly drawn into inflating essentially because this was what was expected of it. Given a jump in private sector expectations, the Fed perceived its choice as one of either accommodating these expectations or risking a serious recession. Given the Fed's known proclivity for accommodation, private sector inflation expectations became a self-fulfilling prophesy. The Fed got caught in an "expectations trap."

Exactly why private sector inflation forecasts jumped the way they allegedly did is not explained; Christiano and Gust view the "expectations shock" as an exogenous impulse. What is explained, however, is how particular institutional arrangements that govern the conduct of monetary policy can give rise to the logical possibility of an expectations trap. Monetary policy in the 1970s is alleged to have operated in such an institutional setting. The authors formalize these ideas within the context of a computable dynamic general-equilibrium model and demonstrate how two exogenous shocks—one to productivity and one to expectations—can lead to a 1970s-style stagflation. Their model's ability to account for the facts lends some credence to their argument. They also support their interpretation of events by appealing to a number of selected statements made by Arthur Burns (Federal Reserve chairman, 1970–77).

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* I would like to thank Lawrence Christiano, Ig Horstmann, David Laidler, and Ed Nosal for a number of helpful conversations.

Overall, I view their paper as an impressive piece of work; it constitutes a wonderful example of how modern macroeconomic theory can be applied to important and difficult questions concerning the conduct of monetary policy and the interpretation of monetary history. The explanation of events is original and the application of quantitative theory innovative. Even if one is, as myself, not persuaded by the argument offered here, the paper lays down a standard and invites competing explanations to do better. In all these senses their paper constitutes a valuable contribution.

The Expectations Trap

The basic idea of an expectations trap can be presented in terms of a very simple game. Suppose that there are two players, the Fed and households. The Fed has two possible actions: It can either choose a low inflation Π_L or a high inflation Π_H. Likewise, households have two possible actions: They can expect either low inflation or high inflation. The utility payoff to each player depends not only on its own action, but also on the actions of the other player. With two players and two actions, there are four possible payoff configurations (see Figure 1).

The payoff structure displayed in Figure 1 gives rise to what is called a coordination game. Players are imagined to make their choices simultaneously (they cannot condition their behaviour on their opponent's behaviour). So two pure-strategy Nash equilibria exist for this one-shot game: one in which households and the Fed coordinate on a low-inflation equilibrium (each receiving a payoff equal to "1"), and one in which they coordinate on a high-inflation equilibrium (each receiving a payoff equal to "0").[1]

A question naturally arises here as to which of the two coordinated outcomes is more likely to transpire; this is the question of equilibrium selection posed by game theorists. Unfortunately, to the best of my

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[1] There is also a mixed-strategy equilibrium in which both the Fed and households expect the low-inflation regime with probability (1/3). In this case a "coordination failure" can occur with positive probability. By suitably modifying the game, one can also construct correlated (sunspot) equilibria that eliminate the possibility of coordination failure. For simplicity I will concentrate solely on pure strategies.

Figure 1
The game

		Households	
		Π_L	Π_H
The Fed	Π_L	1 1	–1 –1
	Π_H	–1 –1	0 0

knowledge there is still no good answer to this question.[2] So we see here that the prevailing institutional structure (the rules and structure of the game) gives rise to a fundamental indeterminacy: Either outcome constitutes a logical possibility. In the game, if households expect (for whatever reason) that inflation is to be high, then the Fed, anticipating this expectation, will have an irresistible incentive to accommodate these expectations. To do otherwise would invite coordination failure. But if the Fed plans to generate a high inflation, then households are perfectly rational in expecting it. In this way, high expectations of inflation can be self-fulfilling. Christiano and Gust exploit exactly this type of indeterminacy in their explanation of the great inflation.

In applying their theory they invoke the assumption that household inflation expectations are subject to exogenous shocks.[3] By specifying such a process the theorist is in effect selecting an equilibrium. For example, in the context of the game, suppose that I simply assume that households choose Π_L (or that households choose Π_L on the basis of some extraneous information).[4] Conditional on this assumed behaviour, the only equilibrium is the low-inflation outcome. It would appear that the theorist is now free to choose any desired outcome simply by specifying the appropriate exogenous process for inflation expectations. One way to impose discipline on the exogenous expectations process is to estimate its parameters by fitting the model to the data. Obviously this exercise is not going to answer the question of why inflation expectations bounce around the way they do, but the estimated model can be used to answer the question of why the economy behaves the way it does given that inflation expectations bounce around the way they do. Methodologically this is no different than, say, a real business cycle theorist estimating the parameters of an exogenous process for technological change and then offering an explanation of the business cycle conditional on this estimated exogenous process.

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[2] There are some axiomatic approaches to selecting among equilibria for coordination problems. Some are simple (choose the Pareto dominant one, if there is one), while others are more complicated (see Myerson 1991). The literature on learning and on evolutionary games also attempts to address this issue.

[3] Alternatively, one might hypothesize that it is Fed behaviour that is subject to exogenous shocks. Technically, I do not believe anything would change aside from the interpretation of events.

[4] Technically, by allowing individuals to condition their strategies on some external shock or information, I have implicitly modified the one-shot game described above.

The exact procedure Christiano and Gust employ in explaining the great inflation is to assume that over the relevant sample period there was one exogenous upward shift in inflation expectations *and* that this shift occurred coincidently in the period of an adverse technology shock. (The model provides absolutely no theoretical rationale for why expectations move the way they do in response to the supply shock, however plausible the argument may sound on other grounds.) The quantitative magnitude of the shift in expectations seems to have been calibrated to match some unspecified price-level response in the period of the technology shock.

The model provides an intriguing interpretation of economic events in the early 1970s. The choice of a modelling framework that features an equilibrium indeterminacy, exogenous expectations shocks, and accommodative monetary policy seems to fit well with a number of recorded statements made by policy-makers in that era. For example, we know that Burns did not view monetary policy as the ultimate driving force behind inflation; at the same time, he recognized that inflation could not be sustained without money growth. In his view, monetary policy was severely constrained by a host of political and economic factors that compelled the monetary authority to behave the way it did (see Hetzel 1998). The game described above reflects this point of view; the monetary authority can do little aside from adopting the "accommodative" Taylor rule Christiano and Gust employ in their quantitative investigation. This view also explains why Burns fought so hard to have a system of wage and price controls put into place. To the extent that wage and price controls can be made credible, the public would be compelled to form low expectations of inflation, and the monetary authority could therefore avoid being pushed into inflating.

Criticism

In any theory or explanation a theorist must take a stand on what might appropriately be treated as exogenous for the purpose at hand. The tradition in monetary economics has been to hypothesize the existence of exogenous shocks to monetary policy (with expectations accommodating the structure of monetary policy). Christiano and Gust hypothesize the existence of exogenous shocks to expectations (with monetary policy accommodating the structure of expectations). I have no problem with exploring the implications of reversing the direction of causality in such a manner;

however, in emphasizing the role of an exogenous variable, it would seem desirable for the researcher to first take some measurements of the variable in question (e.g., see Prescott 1986).

There are, in fact, many independent measures of inflation expectations for the time period Christiano and Gust study. For example, Thomas (1999) reviews three popular survey measures of inflation expectations for the United States beginning in 1960. Interestingly, regardless of how they are measured, year-to-year forecasts of inflation since 1960 consistently display an "inertial" tendency. In particular, over the period of generally rising inflation (1965–80), inflation expectations typically lagged (underestimated) the actual inflation rate. Likewise, since the disinflation of the early 1980s, inflation expectations have generally lagged (overestimated) the actual inflation rate.[5]

To give the reader a feel for these data, Figure 2 reproduces the actual GDP deflator inflation and the previous year's forecast of inflation in the United States over the 1969–94 sample period. The inflation forecast is based on a survey of professional forecasters; the data are taken from Figure 6.9 in De Long (1997). A striking feature of these data is how expectations of inflation consistently underestimated the actual inflation rate through most of the 1970s; however, what is even more striking is how, in virtually each and every year, private forecasters were expecting a *disinflation*. Consider, for example, the inflation "takeoff" of 1973 and 1974, when inflation rose from 4.5 per cent to 6.5 per cent and 8.8 per cent. In December 1972, with inflation at 4.5 per cent, forecasters were predicting for 1973 an inflation rate of 3.9 per cent. In December 1973, with inflation running at 6.5 per cent, forecasters were predicting for 1974 an inflation rate of 5.4 per cent. My reading of De Long (1997) is that policy-makers of this era generally shared in these "optimistic" forecasts.

So my question to Christiano and Gust is: Where is the evidence for this alleged expectations shock? In my view their argument's plausibility requires evidence of a sharp increase in inflation expectations, an increase that either precedes or is at least coincident with an increase in money growth. In the data, however, money growth leads inflation and hence leads inflation expectations by even a greater extent. One could try to argue that the sharp rise in base-money creation beginning in 1970 (see Christiano and Gust's Figure 2) was engineered by the Fed in order to accommodate the rise in inflation expectations expected to occur around 1974–75, but I think that this is stretching things. A more plausible interpretation of these data is that inflation expectations are not subject to unaccountable shocks but rather

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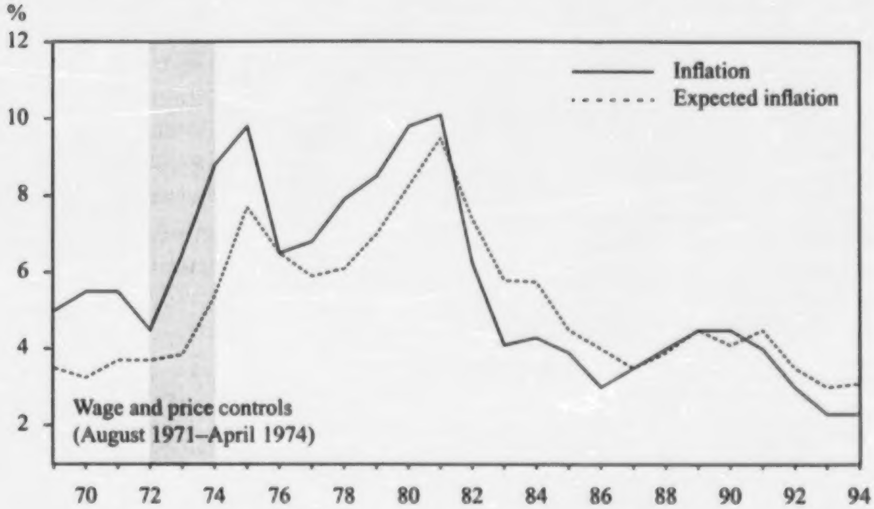
[5] Dotsey and DeVaro (1995) also find that their measure of inflation expectations shows a persistent tendency to overestimate the actual inflation rate during the 1980s disinflation.

Figure 2
Inflation and expected inflation in the United States, 1969–94



are fully endogenous, responding optimally in an adaptive manner (Muth 1960) to new information as it becomes available.[6]

An Alternative Hypothesis

When I view the historical evidence over the last century, this is what I see. There were three (possibly four, depending on how you measure things) inflationary episodes: 1916–20, 1940–46, and 1965–80. (Here I take issue with Christiano and Gust's dating of the "inflation takeoff"; to my eye the takeoff seems to have occurred in 1965, with the 1969–70 disinflation representing a cyclical deviation from the general trend of rising inflation.) Each episode is characterized by three things: (1) a major shift in government expenditure and/or outlays, (2) pressure to finance these outlays with paper (new debt or new money), and (3) a breakdown of a prevailing international monetary institution.

In the first great inflation we had the First World War and the breakdown of the gold standard. In the second great inflation we had the Second World War and a breakdown in the gold standard (admittedly this gold standard was abandoned in the 1930s, so the timing is not quite right here). In the third great inflation there was the Vietnam War in addition to the "war on poverty" and a breakdown of the Bretton Woods fixed exchange rate system, which formally ended in 1971 when Nixon abandoned the dollar's peg to gold.

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[6] See, for example, Andolfatto and Gomme (2000).

The appropriate exogenous event would seem to be whatever caused the major shift in government expenditure. In the case of a war, this might be modelled as an exogenous (and transitory) shift in the general public's preferences for output that is to be consumed in the enforcement of national property rights. People know what comes with war: an increased scarcity of goods for private use, mounting fiscal deficits (nominally denominated, for that matter), a weakening of peacetime institutions, and an irresistible temptation to resort to new money creation.

The Vietnam War was peaking in the late 1960s and early 1970s. Military expenditures were placing great strain on the American economy as real resources were being consumed in unproductive ways. Presidents Johnson and Nixon were naturally reluctant to raise taxes in order to finance the outlays required to meet the growing demands of the war effort and the growing demands for social spending. The arithmetic of the government budget constraint implies that there must have been a growing reliance on other forms of finance, in particular the issuance of new paper (new money and debt) and/or the default on existing paper (monetizing the debt).[7]

Seigniorage revenue is often dismissed as "small potatoes," but it is likely that reported statistics greatly understate seigniorage as a revenue source under a system of fixed exchange rates. When the United States rapidly increased the rate of base-money creation beginning in 1965, the relevant "tax base" under Bretton Woods was the world money supply; foreigners were conceivably contributing significant resources to the United States as inflation around the world soared owing to the proliferation of U.S. dollars. As foreign countries struggled to maintain control over their domestic monetary policies through a series of currency re-evaluations, the fixed exchange rate system began to come apart. The inflation also made it increasingly painful to maintain the value of American currency at $35 per ounce of gold; in 1971, the gold standard was abandoned and Bretton Woods ceased to exist.

It was the fiscal authority (Nixon) that abandoned the gold standard. Why? One argument is that by doing so, the Fed (Burns) was relieved of an important constraint on the rate of money creation (it was no longer compelled to maintain the nominal anchor to gold). This institutional change implied that the Fed was more susceptible to political pressure for accommodative behaviour. This political pressure took the form of demands for more spending (on both Vietnam and the Great Society), demands not to increase taxes (for fear of crippling consumer demand in the weak 1970s economy), and demands not to increase the rate of government debt issue (bad for business psychology). What was the Fed to do in such a situation? One answer is that the Fed could do what it did: reluctantly accommodate these demands by increasing (or not decreasing) the rate of money creation. The narrative I provide here is not inconsistent with Burns's own views. For example, according to Burns's testimony to the U.S. Congress in August 1974 (Hetzel 1998, 35):

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[7] The unanticipated inflation of the early 1970s implied a significant implicit default on outstanding nominal debt (see Auerbach and Kotlikoff 1995, 300).

> The current inflationary problem emerged in the middle 1960s when our government was pursuing a dangerously expansive fiscal policy. Massive tax reductions occurred in 1964 and the first half of 1965, and they were immediately followed by an explosion of Federal spending. . . . Our underlying inflationary problem, I believe, stems in very large part from loose fiscal policies.

In 1979 he gave a speech called "The Anguish of Central Banking" in which he stated (Hetzel 1998, 34):

> Once it was established that the key function of government was to solve problems and relieve hardships—not only for society at large but also for troubled industries, regions, occupations, or social groups—a great and growing body of problems and hardships became candidates for government solution. . . . Their [government programs'] cumulative effect . . . was to impart a strong inflationary bias to the American economy. . . . My conclusion that it is illusory to expect central banks to put an end to the inflation that now afflicts the industrial economies does not mean that central banks are incapable of stabilizing actions; it simply means that their practical capacity for curbing inflation that is driven by political forces is very limited.

According to my interpretation, while general expectations were important, they simply reflected the nature of a fundamental fiscal shock. Expectations were not an indeterminate entity, as Christiano and Gust argue. In fact, I will go so far as to argue that inflation expectations were likely a very important factor in curtailing the rate of inflation. Imagine, for example, what might have happened if Americans (for some unexplained reason) always expected zero inflation. I conjecture that the political demands for new money would have been even easier to accommodate. In contrast, the Christiano and Gust model would suggest the absence of inflation.

Conclusion

Christiano and Gust's interpretation of the most recent great inflation is to treat the general rise in inflation over the late 1960s and early 1970s as two separate episodes. The first episode is explained in terms of their Phillips curve hypothesis, the second by an expectations trap. The monetary authority at that time is described as being weak in the sense of operating in an institutional environment that encouraged it to accommodate possibly whimsical private sector expectations (as opposed to being weak in the sense of readily capitulating to the demands of the fiscal authority or other political forces). They hypothesize the arrival of an adverse technology shock that temporarily increased the inflation rate and the arrival of an expectations shock that propagated the higher inflation forward in time (as the monetary authority accommodated the higher inflation expectations, thereby making them self-fulfilling).

As usual, many different interpretations of history are possible. The best way in which to understand the causes of the 1970s inflation is still an open question. However, it is encouraging to note that while the explanations offered above may differ, they share a common policy implication. In particular, one way to prevent inflationary outbursts is to endow the monetary authority with a credible commitment mechanism (possibly through legislation) that prevents it from ever capitulating to the incessant demands for new money.

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General Discussion

David Laidler commented that the study of Fed behaviour and motives in the 1970s should take into account the state of informed opinion, or economic knowledge, attained in those years. This state was such that expectations of inflation and, in general, forward-looking behaviour, as well as the levels of money stocks, were thought to have little bearing in determining the actual level of inflation at a point in time.

Jean-Pierre Aubry agreed with Laidler and also agreed with David Andolfatto's comment that inflation expectations were not relatively high and leading indicators of ever higher inflation, but were relatively low and lagging indicators of inflation during the seventies.

Marvin Goodfriend wondered how much the present economic system is susceptible to such positive shocks in inflation expectations and whether there is a danger of such an inflation spiral appearing once again. He also agreed with Andolfatto's opinion that it didn't seem that inflation expectations were relatively high in the seventies. Goodfriend offered a possible rationalization of the Fed's incentive to accommodate inflation expectations and not strongly intervene to contain inflation: Political pressures on the Fed's independence were growing in the sixties, so maybe it could not afford to disregard contractionary policy's effect on economic activity. The undermining of the Bretton Woods system also meant that the Fed was left with neither a clear nominal anchor nor a clear fundamental objective for most of that decade.

Charles Freedman asserted that economists deserved some of the responsibility for the increase in inflation in the seventies. Many did not recognize that high inflation had substantial costs, or they concluded that

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[*] Prepared by Kevin Moran.

these costs were small compared to the benefits of moving up the Phillips curve (Harberger triangles were small and Okun's gaps large).

Christopher Gust commented that he liked Tiff Macklem's comment and the simulation included in it and would have liked to have seen the results of Macklem's simulation done with the limited-participation model.

Lawrence Christiano thanked the commenters. He put into doubt Andolfatto's assertion that high fiscal pressure had most often been the underlying cause of (eventual) high inflation by pointing to the eighties, when the American fiscal position continuously deteriorated while inflation was brought into control. He also welcomed Andolfatto's suggestion to try to identify and quantify the exogenous shocks to inflation expectations in their model. Christiano also mentioned that their model and the story derived from it could also be interpreted in a monetarist framework.

Discussion 1

Charles Freedman

This is the fourth conference to be held at the Bank in the 1990s on financial variables and financial intermediation and their roles in the transmission mechanism. Consequently, I thought that it would be of some interest to examine the development of the Bank's thinking over the decade with respect to financial variables and the way they have been used in policy.

What has changed over the last 10 years in our approach to the use of monetary aggregates? In one sense their role in the making of policy is not all that different from what it was 10 years ago; in another sense it has changed quite a lot.

Let me explain what I mean. As you all know, since February 1991 the Bank has had a target for inflation as the centrepiece of its policy-making strategy. Originally 2 to 4 per cent, the target has been set at 1 to 3 per cent since the end of 1995. Achieving a target for very low inflation or price stability has been judged to be the best contribution monetary policy can make to the ultimate objective of economic policy—a well-functioning economy with high levels of output and employment.

As is now widely recognized, inflation targeting acts like an automatic stabilizer in the case of demand shocks, and if appropriately specified can also deal effectively with supply shocks. It has typically been part of a regime that emphasizes transparency. And it requires forward-looking policy-making inasmuch as it focuses attention on the forecast of inflation and the deviation of that forecast from the target.

Monetary aggregates have entered the process of policy-making as one element of the Bank's approach to assessing future movements in inflation. And this is where the empirical work done through the 1990s has been very helpful. The central element in the Bank's process of forecasting inflation has been the formal staff forecast, based on the Quarterly Projection Model, as modified by judgmental adjustments. But money has played a useful complementary role as a check on the staff forecast. For example, when monetary aggregates were growing rapidly at a time when the staff forecast did not indicate rapid growth in output or prices, it served as a yellow light and provoked further analysis of the possible discrepancy. That is, did the rapid growth of money signal an inflationary risk to the staff forecast or were we going through another bout of financial innovation that could be explained by changes in financial structure or regulatory arrangements?

While this general statement of the role of the aggregates is little different from what I would have said 10 years ago, there have been a number of important changes in our approach to the aggregates during the 1990s. Three in particular are worth noting: methods of estimating the behaviour of the aggregates, the way the monetary aggregates are used in forecasting output and inflation, and the interpretation of the role they play in the transmission mechanism.

The first element of change has been the increased sophistication of the approaches to modelling the behaviour of the monetary aggregates. On the demand side, greater attention has been paid to the longer-run or equilibrium relationship of money to its explanatory variables. While cointegration techniques were already being used at our conference nine years ago, they now play a more important role as attention has shifted away from the short-term to the long-term relationship. And the vector-error-correction model has taken centre stage in our analysis of M1, as exemplified by the Adam-Hendry paper and its predecessors. At the same time, we continue to carefully examine the impact of financial innovations of all types on the desired holdings of money. For example, the Aubry-Nott paper emphasizes the effect of the elimination of reserve requirements on the behaviour of the chartered banks and thereby on the growth of M1 in the mid- to late 1990s. It is only through integrating careful institutional study and solid empirical analysis that we can properly understand the movements of the monetary aggregates and learn to use them as indicators of future inflation. And I would note in passing that we are putting somewhat greater emphasis on M1-type aggregates and somewhat less emphasis on the broader aggregates than was the case 10 years ago.

At the same time, we continue to be prepared to reassess the various measures of money to see whether different definitions of money can be more helpful in forecasting spending and inflation than the measures currently being used. McPhail's paper is a good example of this type of analysis, while Serletis and Molik correctly remind us that we have to re-examine from time to time the usefulness of alternative ways of aggregating the components of the monetary aggregates.

A second element of the change in the way we approach the aggregates is the increased formality with which we now assess the information contained in the aggregates and compare it with the staff forecast of output and inflation. Until recently, the cross-check provided by the aggregates to the staff forecast entered the process rather informally. Following the presentation to senior management of the staff forecast, the information contained in the aggregates was assessed as one of the potential risks to the staff forecast. Currently, however, during the meeting at which the staff forecast is presented and discussed there is also a formal and independent presentation of the output and inflation forecasts derived from the movements of the financial aggregates. At this meeting the Bank's regional representatives also give an assessment of the upcoming period based on their survey of businesses and associations across the country. All three sources of information are treated as useful inputs into the analysis of the future path of inflation.

That said, the weights that are placed on the various sources of information and analysis will depend on their success in forecasting output growth and inflation. Thus, a good track record over time of the forecasts based on monetary growth or on the surveys of businesses will increase the weight that these approaches are given in management thinking and the seriousness with which their signals of future inflation problems are taken.

Forecasts based on the monetary aggregates also contain a significant element of judgment. Those responsible for interpreting the monetary aggregates are asked not simply to give us a mechanical forecast but to use their analysis of the aggregates' recent behaviour and the information they have on financial innovations affecting the aggregates to give us their considered judgment as to their best estimates of future output growth and inflation. After all, with several monetary aggregates and a variety of equations linking these aggregates to output growth and inflation, there could be a large number of aggregate-based forecasts of the path of output and inflation over time. The challenge to the staff is to derive their best forecast on the basis of these multiple forecasts.

At present, economic activity in Canada is approaching traditional measures of capacity, but there is considerable uncertainty about whether these measures are appropriately capturing possible changes in the economy's capacity to produce goods and services resulting from changes in policy (such as deregulation, NAFTA, the achievement of low inflation, deficit elimination, and the introduction of the GST) and from corporate and government restructuring over the past decade. With greater uncertainty about the measures of the output gap, the Bank is placing increasing weight on various indicators of future inflation, as discussed in the May 1999 *Monetary Policy Report.* And clearly the behaviour of the monetary aggregates is one of the measures that will receive increased attention in these circumstances.

The third element of our change in approach to the aggregates is the interpretation of the role that the financial aggregates play in the transmission mechanism. At the beginning of the 1990s, most of the senior staff of the Bank would have subscribed to what has come to be known as *passive* money and credit. That is, while money and credit played the role of information variables or indicators of spending and inflation, little or no causality was attached to that role. Other staff members have argued for an interpretation that would permit the financial aggregates to play a more central role in the transmission mechanism—an approach that has been described as *active* money and credit. This involved a causal role for the financial aggregates in the transmission of policy from central bank actions to spending and inflation.[1]

What is our current thinking about the role of credit and money in the transmission mechanism?

The current Bank view on credit allows for the possibility that there can be episodes in which changes in financial institutions' willingness to extend credit, as shown by their adjusting the spreads over base rates or the non-price terms and conditions attached to loans, can have an impact on spending. Two key examples in this decade of such episodes were the "headwinds" in the United States in the early 1990s and the liquidity problems in markets around the world in the fall of 1998. Such episodes, along with the analysis generated by the credit-channel theories (which were largely based on models relying on information asymmetries), have sensitized us to the possibility that sometimes changes in financial institution lending behaviour can have important consequences for the economy. This in turn has caused us to pay more attention to the non-price terms and conditions at which credit is extended.

Turning to the debate about active versus passive money, I would note that an important element advancing the discussion was the recasting of the active-money paradigm in terms of endogenous money, as opposed to exogenous money. It is very difficult for a central bank, which uses the interest rate as its instrument of policy, to take seriously a model based on exogenous money or to treat it as anything more than a fable that might be useful as a textbook presentation.

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[1] See Laidler (1999a and 1999b) for a detailed discussion of this issue.

While I find the endogenous active-money story much more palatable than the exogenous money story, my own interpretation of it is still considerably less active than that of many of my colleagues or of David Laidler. I agree with Laidler that we are dealing with an empirical issue—how businesses and households respond to an unanticipated increase in their cash balances. To the extent that a business interprets higher-than-anticipated cash balances as a sign of stronger-than-expected demand for its product and chooses to adjust its behaviour accordingly, say by increasing its inventories or investment, it might behave very much as predicted by the active-money story. But another interpretation of this story is that the business is reacting to its actual and anticipated revenue flow and that its cash balances are simply its first indication of this increased revenue. While there may be little operational difference between these interpretations in the case of small business, the notion that cash balances are the first predictor of unexpected revenue would seem less plausible in the case of large businesses or, indeed, of households, most of whose income is in the form of salaries. Nonetheless, we can all agree that cash balances might play a useful role as an indicator in picking up some of the shocks that influence spending but are not picked up elsewhere in our models.

A very interesting recent analytical advance has been the development of monetary general-equilibrium models. The last three papers in this conference are good examples of this genre of models. While they yield some interesting insights, I would argue that this type of analysis will have to go a lot further in modelling financial institution behaviour before it becomes part of the tool kit of the practising central banker. In particular, many of the assumptions that give rise to "limited participation" in the first round of a policy action seem to have no recognizable counterpart in actual financial systems. I would strongly encourage the researchers in this area to continue aiming at providing realistic underpinnings for the assumptions about the behaviour of financial institutions and financial market agents at the heart of their analyses. Perhaps general-equilibrium modellers should work more closely with specialists in financial structure and financial practices. The specialists could provide institutional information to the modellers, and the modellers could help guide the collection of institutional information and identify changes that might be important for money demand and for the effect of money in the transmission mechanism. Central banks have an obvious comparative advantage in facilitating this type of fruitful interaction between modellers and institutional specialists.

Peytrignet's discussion of the Swiss experience raised an interesting point—the problem caused by a high interest rate elasticity of money demand in a regime of monetary targeting. In Canada the principal reason for withdrawing the M1 target in 1982 was the significant decline in M1 caused by financial innovations, along with the uncertainty about further innovations in the future. An important secondary reason was the difficulty caused by the high interest rate elasticity of the demand for M1 when the Bank of Canada was trying to counter inflationary pressures.[2] More concretely, when the system was hit by an inflationary shock, it led to an increase in the amount of M1 demanded. With the rise of M1 above its target, the Bank took action to raise its benchmark rate of interest. But with a high interest rate elasticity of money demand, the increase in nominal interest rates needed to bring M1 back to target might be so small that real interest rates would rise only by a small amount or perhaps would fall. The outcome would be similar to the situation with a Taylor rule in which the nominal interest rate responds to inflation with a coefficient just above unity or below unity. As Peytrignet points out, getting appropriate interest rate movements in a monetary-targeting regime with a high interest rate elasticity would require a countercyclical path for M1. And this would not be easy to explain to the public.

In concluding, I would simply note that we have made considerable progress since our first conference nine years ago in our thinking about many of the issues discussed here over the last two days. And I would expect that we will make further progress before our next conference on monetary issues three or four years from now. But the real payoff can be found in the contribution such research makes to good policy-making. And in this vein the developments over the next few years should be very interesting.

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[2] See Thiessen (1983).

Discussion 2

Marvin Goodfriend

I thank the Bank of Canada for inviting me to offer some remarks at the close of the conference. My thoughts reflect the many excellent papers that were presented. Instead of referring to any of the papers specifically, my comments are organized by topic. In keeping with the conference themes I address three aspects of monetary policy. I begin with some general thoughts on the role of money in models of interest rate policy. Then I discuss money, inflation, and interest rate policy. Finally I comment on the empirical analysis of monetary policy shocks.

Money and Interest Rate Policy

One can understand interest rate policies commonly pursued by central banks today without considering the monetary aggregates at all.[1] Monetary policy models that ignore money typically have four components. First, an expectational IS function relates current aggregate demand to expected future income and the ex ante real interest rate. Second, a Fisher equation relates the nominal short-term interest rate to the sum of the ex ante real rate and expected inflation. Third, an expectational Phillips curve relates current inflation to a current output gap and expected inflation. Last, an interest rate rule describes how the central bank makes policy. Such models contain no money-demand function, and the money stock appears nowhere in the basic model.

Monetary policy models that ignore money are insightful and convenient. Such models depict monetary policy reasonably well in the sense that they capture the way that central banks operate today. Variants of the basic model without money are widely and profitably used for analyzing monetary policy both inside and outside central banks.

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[1] See, for example, Kerr and King (1996) and Woodford (1999a).

* Robert Hetzel's comments were appreciated.

It is important to remember, however, that interest rate policy models that ignore money presume that a central bank has established in the public's mind the credibility that gives it the power to pin down an expected future price level or the expected rate of inflation at each point in time.[2] When a central bank has credibility to anchor the path of the price level, it can allow the stock of money to be demand-determined each period at the chosen setting for its interest rate policy instrument. Money needn't play a causal role in the transmission of policy in this case.

Money plays a critical role, nevertheless, because credibility for a price-path objective stems from a central bank's power to manage the stock of money, if need be, to enforce that objective. Models that ignore the role of money in the policy-making process can do so only because the central bank has somehow already established credibility for its control over the price level.

Practically speaking, interest rate policy works well when it is easy for a central bank to judge the effect of its interest rate policy actions on expected inflation. With inflation and inflation expectations anchored near zero, nominal interest rate policy actions translate clearly into real interest rate actions.

This is the case today for many central banks around the world. However, an inflationary shock could create a problem for interest rate policy. It was the collapse of its credibility for low inflation that caused the Federal Reserve to move temporarily from interest rate targeting to nonborrowed-reserve targeting in 1979.

Moreover, price stability itself can create a problem for interest rate policy. When the price level is stable, nominal short-term interest rates are, on average, relatively close to zero. For instance, in the decade following the Korean War the U.S. Treasury bill rate ranged between 1.5 and 3.5 per cent and consumer price inflation averaged about 1.5 per cent. With price stability, short-term nominal interest rates could average as low as 1 per cent, increasing the chances that short rates could hit the zero bound in a recession, as they have in Japan today.

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[2] See Goodfriend (1987) for an analysis of the interplay between expected inflation, money, and interest rates in an optimizing model of monetary policy.

Since conventional interest rate policy won't work at the zero bound, a central bank should be prepared to conduct policy with a monetary-base instrument at the interest rate floor. Liquidity narrowly defined would be satiated. That is, it would not be possible for additional currency or bank reserves to free transactions time for more productive uses. But monetary transfers or open market purchases of long bonds could stimulate the economy by increasing liquidity broadly defined.[3] At the zero bound a central bank still would have to see to it that a contraction of monetary assets or an excess demand for broadly defined liquid assets in the economy did not precipitate or exacerbate a downturn or preclude a recovery.

To sum up, money deserves a special place in the strategy of monetary policy even if in today's environment money does not play a central role in policy-making. Central banks should be prepared to use a monetary-base or bank-reserve policy instrument if necessary. Economists should explore models in which monetary aggregates play a role in transmitting monetary policy independently of interest rate policy. A central bank should be prepared to explain to the public how it could use monetary targeting to deal with high inflation or the zero bound. Building the public's confidence in a central bank's power to address these situations would help to avoid them in the first place.

Money, Inflation, and Interest Rate Policy

It is widely believed that money growth cannot exert an inflationary force on aggregate demand independently of the interest rate channel. In part this is because open market operations accommodate money demand at the intended level of short-term interest rates. A central bank cannot force bank reserves into the economy while maintaining its short-rate target. Nevertheless, I outline below how a potentially inflationary increase in broad money can occur independently of a change in the stance of interest rate policy.

To begin, suppose there is an increase in the demand for short-term credit and that increase manifests itself, in part, as an increase in bank loan demand. In addition, assume that the central bank follows an interest rate policy and maintains its current inter-bank rate target in spite of the increased demand for credit. The increased demand for credit puts upward pressure on short-term rates. But the central bank's defence of its inter-bank rate target keeps money market rates from rising. In effect, the excess demand for credit is satisfied at unchanged short rates with loanable funds obtained by selling treasury securities to the central bank. Open market purchases eliminate the excess demand for credit by allowing banks to substitute private credit for treasury securities in their portfolios.

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[3] Building on the distinction between narrow and broad notions of liquidity, Goodfriend (1999) discusses mechanisms by which monetary targeting could overcome the zero bound on interest rate policy.

Suppose that the proceeds of the new loans are paid out as income to workers in exchange for output and that the additional income is regarded as temporary. According to the permanent-income hypothesis, the newly created income is saved initially, say, as non-transactions bank deposits. Banks hold relatively few reserves against non-transactions deposits. So the central bank would reverse (with open market sales) most of the monetary base injection that accompanied the initial open market purchase. The net result is an expanded consolidated banking system balance sheet, with growth in non-transactions deposits matched by the increase in loans.[4]

The question at issue is whether growth of the broad monetary aggregate could pose an inflationary threat to the economy. To address this question, begin with a pure real business cycle perspective. Assume initially that all individuals are alike. Suppose that a preference shock causes the representative agent to work harder, say, to add permanently to his or her stock of consumer durables. After temporarily working harder to build up the stock of durables, the representative agent returns to his or her initial allocation of work effort. Furthermore, suppose that the representative agent plans to permanently cut non-durable consumption to finance the maintenance of the larger stock of consumer durables.

By allowing for heterogeneity among agents, we can see how these real actions can lead to the growth of broad money. Imagine that the preference shock hits only some individuals. These agents will use credit to purchase consumer durables from others who will be induced by temporarily higher real wages to produce them. The producers would save the temporary increase in income as non-transactions deposits. Producers would raise their consumption permanently with the interest payments received on their additional deposits. And those agents who financed an increased demand for consumer durables by borrowing would decrease their consumption to pay the interest on their bank loans. From a real business cycle perspective this one-time expansion of the banking system balance sheet and in the stock of broad money relative to income need not be inflationary.

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[4] Goodfriend (1982) analyzes the relationship between bank loan demand, M2 determination, and monetary policy.

A monetarist might object to the above story because it does not allow for a liquidity yield on broad money.[5] From a monetarist perspective, all assets offer a total return that includes, to one degree or another, an implicit liquidity services yield together with a yield in productive services, direct utility, interest, and/or capital gains. Monetary assets such as currency and bank deposits are valued primarily for their implicit liquidity services yield. The implicit liquidity services yield accounts for a smaller share of the total return to short-term bonds and an even smaller share of the return to longer-term bonds and non-monetary assets.

The newly created non-transactions deposits constitute a net addition to broad liquidity. Following monetarist logic, an increase in broad money relative to spending would drive down the marginal implicit liquidity yield.[6] Equality between the total return on broad money and the total return on less-liquid assets could be maintained with a higher explicit own rate paid by banks on non-transactions balances. However, because the central bank targets the inter-bank rate, which anchors the cost of loanable funds, banks would not offer higher rates on deposits.

Consequently, the public would attempt to rebalance its portfolio by exchanging non-transactions deposits for less-liquid assets with higher total returns. The attempt to do so would drive up the prices of less-liquid assets and drive down their expected returns relative to the total returns on deposits. The excess supply of broad liquidity would be worked off, in part, by reducing the expected explicit yield spread in favour of non-monetary assets. Aggregate demand would tend to increase as a result of the rise in asset prices, and the excess broad liquidity could ultimately be dissipated by a rise in the price level.

When one takes into account the implicit liquidity yield, an increase in broad money relative to spending could be inflationary. When and whether it would be inflationary depends on factors such as the cost and speed of portfolio adjustment and how persistent and extensive the public might expect the excess broad-money creation to be. A central bank with credibility for stable prices could allow the broad money overhang to persist for a while if the public believed that the central bank would see to it that the excess supply of broad money was eventually eliminated without inflation.

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[5] Diamond (1997), Heaton and Lucas (1996), and Holmstrom and Tirole (1998) may be interpreted as analyzing broad liquidity services provided by bank deposits and government bonds in models in which there are external finance premiums. Again, see Goodfriend (1999).

[6] Heaton and Lucas (1996) study the broad liquidity service yield in a quantitative incomplete-markets model, reporting that 50 per cent of the equity premium (the additional explicit return to equity relative to short-term bonds) is accounted for by the marginal implicit broad liquidity services yield on short-term bonds. They show quantitatively that the equity premium is very sensitive to the amount of short-term bonds available and is reduced when an outside supply of short-term bonds is increased. Short-term bond holdings provide liquidity services broadly defined by allowing borrowing-constrained individuals to smooth consumption without paying heavy transactions costs. Non-transactions deposits may be thought of as close substitutes for short-term bonds.

Empirical Analysis of Monetary Policy Shocks

In this last section I comment on the empirical analysis of monetary policy shocks using vector autoregression (VAR) analysis. VARs are among the least restrictive means of studying monetary policy empirically. Much of what I say should be understood to apply more generally.

Rational-expectations macroeconomics teaches that an empirical strategy to study monetary policy should assume that both the public and the central bank use information efficiently. Hence a good strategy must specify relevant information and presume that the public and the central bank use this information to make efficient forecasts of the relevant variables. VARs do this by orthogonalizing conditional forecast errors and variables presumed to be in the information sets of the public and the central bank.

Because VARs highlight this procedure they also show how sensitive it is to pitfalls. For instance, the orthogonalization can be misleading if any of the variables are measured with error. There is also a problem if variables omitted from a VAR are actually used by the central bank or the public to make forecasts and the omitted variables are correlated with included variables. Complicating matters further, the relative importance of variables in the central bank's reaction function may change over the business cycle. For example, at the peak of the cycle, when inflation is most likely to be a problem, variables that help predict inflation are watched more closely by the central bank and should therefore figure more prominently in the market's forecasts of interest rate policy actions. The lexicographical switching of the importance of variables in the central bank's reaction function creates a problem for linear constant-coefficient VAR methods.[7]

When VAR analysis was initially applied to monetary policy in the 1970s and early 1980s, economists tended to regard shocks to the money stock as a major—if not *the* major—source of shocks to the macroeconomy. Inflationary go-stop monetary policy in the decades following the Korean War reinforced the view, made famous by Friedman and Schwartz (1963), that monetary shocks mattered a lot. Using VARs to isolate policy shocks and to trace their effects on other macroeconomic variables seemed a promising way to study monetary policy.

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[7] Rudebusch (1998) questions the identification and interpretation of policy shocks in VARs. See also Sims's (1998) comment on Rudebusch.

Today, however, the world's major central banks make low inflation a priority. At least for now, inflationary go-stop policy appears to be a thing of the past. Monetary policy is a stabilizing force in the economy, and it seems fair to say that central bank behaviour is more purposeful than random.[8]

Moreover, monetary policy has come to be understood as operating through an interest rate instrument, not the money stock. If one takes the intended overnight inter-bank interest rate as the policy instrument, then it is hard to see how the central bank would allow unintended policy shocks. The intended federal funds rate has been publicly announced in the United States since February 1994. And markets ignore temporary noise around the intended rate.

One way of allowing for unintended interest rate shocks might be to model interest rate policy as working through longer-term rates. Policy might be assumed to work through 3- or 6-month rates, which are determined (up to a term spread) according to the expectations theory of the term structure as an average of expected future overnight rates. Policy shocks could then be interpreted as unintended shocks to overnight interest rate expectations.

Even here, however, one would have to explain how expectational shocks unintended by the central bank could occur. If both the public and the central bank used the same variables, observed these at the same time, and agreed on the efficient way to forecast the relevant variables, then it would be hard to generate unintended expectational interest rate shocks.

The central bank could be presumed to have private information about its own or the political system's preferences for surprise inflation.[9] It is often argued that serially correlated private information about central banker preferences plays an important role in the evolution of monetary policy. However, it is harder to believe that private central bank preferences currently guide policy in the world's major central banks given the de facto or mandated commitment to low inflation.

Still another possibility is that central banks introduce into the interest rate instrument an inertia that cannot be readily explained with a linear constant-coefficient policy rule.[10] In this view the policy shocks estimated by the econometrician may be neither unintended by the central bank nor surprises from the public's point of view. The estimated shocks may result mainly from model misspecification.

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[8] Leeper, Sims, and Zha (1996) report that movements in the monetary aggregates arise primarily from policy that accommodates shifts in private demand and that interest rate policy shocks have played a relatively small role in output variation in recent decades.

[9] Cukierman and Meltzer (1986) analyze in detail the consequences for monetary policy of private information. Leeper, Sims, and Zha (1996, 12) argue that there is inherent randomness in the policy-making process that accounts for the shock in the policy rule.

Confidence in VAR findings about the effect of monetary policy shocks on the economy critically hinges on whether one thinks that shocks to the interest rate rule have been properly identified and interpreted. An empirical analysis of monetary policy should explicitly specify the presumed source of policy shocks to ensure that it is a sensible one and to take advantage of any restrictions that the assumed shock-generating process might imply for the empirical analysis.

At the least, in this era of purposeful central banking it seems implausible that VARs should be interpreted in such a way that unintended shocks to the policy instrument are allowed to persist over time and significantly influence variables in the macroeconomy. Those who favour interpreting policy shocks as the result of an inevitably poorly understood randomness in the policy-making process must ask how a modern policy committee, monitored by central bank watchers, could allow significant randomness to persist in its policy instrument.[11]

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[10] See Woodford (1999b).

[11] For a VAR specified in levels, a lagged short-term interest rate (with a positive coefficient) in the interest rate policy equation implies that a policy shock persists. For a VAR in first differences, white-noise shocks have permanent effects on the level of the interest rate instrument and cumulate if there is a lagged-difference interest rate variable with a positive coefficient in the policy equation.

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Discussion 3

David Laidler

To be given the last word at a conference on the monetary aggregates is a real pleasure. My thanks to the organizers!

Aggregates are beginning to come back into fashion among policymakers, so it is worth reflecting a little on what went wrong when money-growth targeting was in vogue in the 1970s and on what lessons that experience has for us this time around as we try to make better use of these variables.

Money-Growth Targeting in the 1970s

The adoption of money-growth targeting in Canada and elsewhere in the mid-1970s was the outcome of a debate about the causes and cures of inflation—the "monetarist controversy." For those in the monetarist camp, victory proved a mixed blessing. They had advocated placing the growth rate of a monetary aggregate at the centre of anti-inflation policy, and in Canada they got a version of their prescriptions put into practice, albeit in full view of a very attentive and critical audience. Sadly, however, the policies implemented did not work very well. In hindsight that is not altogether surprising.

When Milton Friedman (1960) argued for a money-growth rule, it was as a means of ensuring that the steadily expanding and low-inflation U.S. economy of the 1950s stayed that way. When money-growth targeting was adopted in Canada in 1975, it was as a means of restoring stability to an economy that was already in a great deal of inflationary trouble. Friedman had suggested that the once-and-for-all adoption of a legislated and constant growth rate for money would be compatible with maintaining an already desirable status quo. The Bank of Canada, on the other hand, introduced administratively set monetary expansion targets that were to be reduced gradually over time as inflation was brought down. This regime turned out to be fragile for a number of reasons.

First, in the mid-1970s, economists were well aware of the systematic relationship between the demand for money and the level of nominal interest rates, a relationship that underlies what came to be called the "re-entry problem," but they had not completely thought through its implications for the behaviour of money growth when, as monetary policy took hold on aggregate demand and began to bring inflation down, interest rates first rose and then began to fall. Second, and closely related, they underestimated the problems that would be created by portfolio substitutions among various classes of deposits, some non-interest-bearing and others paying interest at market-determined rates. These effects put narrower and broader aggregates on divergent paths and made the stance of policy hard to read.

Third, and perhaps most important, economists were completely unprepared to cope with institutional developments within the financial sector. The meaning of particular aggregates began to change with these developments, which in Canada notably included the introduction of daily-interest chequing accounts, partly in response to advances in computing technology but also as a manifestation of the re-entry problem at work. These accounts were, technically speaking, notice deposits and hence were not included in M1, the Bank of Canada's targeted aggregate, but their introduction shifted the demand function for M1 and disrupted a policy regime that relied on gradually reducing its growth rate.

The widespread confidence that existed in the early 1970s in the stability of the money-demand function seems naive now, but it stemmed from the success that had been achieved in modelling this relationship over long time periods and with remarkably simple equations. There was a problem here, needless to say. The various quantity-of-money data sets that everyone used, notably Friedman and Schwartz's (1963) series for the United States since 1863, had been constructed ex post and were already, as it were, adjusted for institutional developments. A series that had begun with a definition of money appropriate for 1863, and had then been mechanically carried forward, would very quickly have revealed the destabilizing consequences of institutional change for econometric relationships. But when monetary aggregate definitions that had been appropriate in the early 1960s were extrapolated into the 1970s, these effects came as a surprise.

This is not the place to dwell on the history of money-growth targeting in Canada. Suffice it to note that it didn't work very well, never attracted widespread support from the general public—among whom the idea of putting the growth rate of a monetary aggregate at the centre of policy had little resonance—and was formally abandoned in 1981.

Inflation Targeting and the Monetary Aggregates

The monetarist victory in the debates of the sixties and early seventies left a permanent mark on ideas about monetary policy. Money-growth targeting was given up in 1981, but not the ideas that the proper goal for monetary policy is the control of inflation and that, in the long run, it is the rate of money growth that drives the inflation rate. In Canada, furthermore, evidence that shorter-run fluctuations in money growth provide useful leading information about subsequent movements in output and, at a longer horizon, in inflation continued to accumulate in the eighties and nineties.

There is, then, a very real sense in which the current inflation-targeting regime is a legacy of the monetarist controversy. This regime commands considerable support among the public, which understands very well what inflation is and that it can have unpleasant effects.

For close to a decade now, inflation targeting has been conducted on the basis of a macroeconomic framework in which the monetary aggregates play no visible role, but in which links run from an interest rate under the central bank's direct control, through aggregate demand, to an "output gap" that in its turn moves inflation relative to its expected level. The maintenance of low inflation in recent years, as the economy has moved towards something like "full employment," is surely testament to the usefulness of this framework. But its very success has reduced that usefulness. No one is now really sure how big the output gap is; indeed it is possible to argue about whether it is positive or negative.

The Bank of Canada therefore badly needs other supplementary indicators of the effects of policy on inflation, and the monetary aggregates are well adapted to this task. Their role in determining the long-run time path of inflation is uncontroversial, and in the shorter run their usefulness, particularly that of the narrower aggregates, as leading indicators of output is also well established. Moreover, now the main problem for monetary policy is to keep a well-performing economy out of trouble, the very issue that Friedman wished to address with a money-growth rule 40 years ago.

None of this adds up to a case for the reinstatement of money-growth targeting; problems associated with institutional change have not gone away. But the monetary aggregates ought to attract, and are attracting, renewed interest among monetary policy-makers; it is worth trying to find them a secure place in the theoretical framework on which policy is based. That, of course, is what this conference has been all about.

Endogenous Money

The debate about whether money is an exogenous or endogenous variable has caused much confusion over the years. Obviously, from the point of view of the economy as a whole, money is endogenous, but that does not make it passively so. Moreover, in terms of the pragmatic "Marshallian" approach to economic modelling, an approach that underlay the work of Friedman and those who followed his lead, it is useful to study the effects of money on output and inflation in terms of simplified systems that isolate these effects by treating money "as if" exogenous. Even so, it is also useful to complete the picture by showing how banking-sector liabilities, created as a by-product of credit market activities (which themselves have direct effects on aggregate demand), can have second- and subsequent-round effects rather than simply being extinguished by offsetting transactions between the banks and the public.

Verbal accounts of how this can come about have been common enough in the literature of monetary economics for close to two centuries, as I have shown in Laidler (1999), but formal expositions are another matter. Brunner and Meltzer made a major effort to provide one 30 years ago (see 1993, "Second Lecture," for a retrospective account), but the essentially recursive nature of the mechanisms at work proved hard to accommodate within the static technical framework available in the sixties and seventies. Their work therefore found fewer takers than it deserved; however, the recently developed tools of dynamic general-equilibrium (DGE) analysis may provide a much better way to come to grips with these issues.

It is of the very essence of DGE models that the timing of transactions between types of agents is carefully specified so that a sequence of impulses can be explicitly traced. These might run from, say, the central bank changing the interest rate, through financial intermediaries, to firms interacting with these intermediaries in a credit market, to households by way of a labour market, thence back to firms in the output market, to financial intermediaries in a market for deposits, and so on. An alternative sequence could start from a technology shock that simultaneously affects production possibilities and firms' incentives to borrow from financial intermediaries.

If it were easy to take such models and develop versions that pay particular attention to the money-creating activities of financial intermediaries and to their subsequent consequences for the spending and portfolio decisions of firms and households, that would already have been done. But there is a large potential payoff from this difficult line of investigation: It could give us much clearer ideas than we now have of just why it is that the endogenous monetary liabilities of financial intermediaries, particularly those liabilities that are usable for transactions purposes, seem to play a causative role in spending decisions, and also of the circumstances in which such effects are likely to be of particular importance. The clearer is our theoretical understanding of these matters, the more confidence will we have in our abilities to extract policy-relevant information from monetary aggregates' behaviour.

An Ongoing Problem—Defining Money

Perhaps such work will also throw light on the problems that plague any policy application of monetary aggregates and that have been given considerable attention at this conference: the proclivity of the messages that these variables convey to change over time in response to institutional developments. Pending such a happy outcome, I have no panacea to offer. This problem has existed since monetary policy was first systematically discussed in the early nineteenth century, even if we did forget it for a while in the 1960s and 1970s.

However, as an extension of current work it might be helpful to recall that narrow aggregates are not so much alternatives to broad ones as components of them. We should pay more attention to the information that is contained in the differences between them when we try to understand the role of the aggregates in the policy transmission mechanism. The varying weights that divisia indices give to particular components of the aggregates recognize this fact, but these indices are only one way of studying the matter.

Beyond that, it is trite to dwell on the importance of continuously monitoring institutional developments, but that will surely be essential to maintaining the usefulness of the monetary aggregates in conducting monetary policy. After all, even before money-growth targeting was introduced, Kenneth Boulding (1969, 555) issued a prescient warning, which remains as relevant as ever:

> We must have a good definition of Money,
> For if we do not, then what have we got,
> But a Quantity Theory of no-one knows what,
> And this would be almost too true to be funny.
> Now, Banks secrete something as bees secrete honey;
> (It sticks to their fingers some, even when hot!)
> But what things are liquid and what things are not,
> Rests on whether the climate of business is sunny.
> For both Stores of Value and Means of Exchange
> Include, among Assets, a very wide range,
> So your definition's no better than mine.

Still, with credit-card-clever computers, it's clear
That money as such will one day disappear;
Then, what isn't there we won't have to define.

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General Discussion

The discussion following the panel focused on the role of monetary aggregates in the conduct of monetary policy. Tom Rymes questioned whether the monetary base could be considered any longer as a nominal anchor when it consisted only of currency in circulation. Charles Freedman agreed that the textbook money-supply model was not applicable and challenged authors to develop alternative pedagogic models that cope with zero bank reserves.

David Mayes said that it was difficult to understand the exact purpose of the money-supply reference zone announced by the European Central Bank (ECB). He wondered if this concept was helpful for public communications. Freedman viewed the ECB's approach as being in the middle of a continuum of possibilities combining money growth and inflation. At one end would be an inflation target, as in Canada, with money stocks used informally as information variables. At the other would be a money-growth target with an implicit low-inflation objective, similar to the Swiss and German targets.

David Laidler, Marvin Goodfriend, and Frank Smets were more enthusiastic about the potential role for the money supply. Laidler thought that while one had to be watchful for the effects of structural change at certain times, the empirical evidence on the whole suggested that there was information in the monetary aggregates, e.g., M1 in Canada. This could be used to develop a guideline for setting the short-term interest rate over, say, the next six months in a manner that would be consistent with achieving the announced inflation target.

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* Prepared by Kevin Clinton.

Goodfriend stressed that the central bank's power to influence the economy ultimately depends on the existence of a predictable demand for some monetary base component that has no close substitutes. Also, a money-growth guideline would be a defence against serious policy errors. For example, under deflations and inflations the nominal interest rate becomes a treacherous gauge of the stance of policy in that the rate's movements might reflect revisions to expectations for changes in the price level rather than changes in the real interest rate. And during a deflation, because of the zero bound to nominal yields, the short-term rate of interest might cease to be an operational policy variable. Under such circumstances, quantitative targeting could be useful.

Smets described the conceptual basis for the ECB reference rate for M3 growth. This aggregate is more than just another indicator variable, since it could be used as the system's nominal anchor. The reference rate provides a robust guideline for monetary policy. In the light of the uncertainties and changes in the transmission mechanism, robustness is an especially valuable property. Moreover, we do not have models that take account simultaneously of all the relevant factors: e.g., asset price behaviour and financial fragility. To help fill in these gaps, it pays to keep an eye on quantitative measures.

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